AGRICULTURAL ENGINEERING

MAY • 1953

In this Issue . . .

Special Machines Designed for Land Drainage and Grading

How to Eliminate Speed Fluctuation in Multijoint Power Lines

Comfort Zone in Infrared Brooding of Small Farm Animals

Agricultural Engineers Advance the Art of Making Grass Silage

Outlook for Heat Pump Applications in Agriculture

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This revolutionary plow now makes contour plowing practical and is ideal for terrace building. The front bottom cuts neither too narrow nor too wide. Scientifically-located pivot point keeps all bottoms of Case Breakaway-Contour Plows cutting true-width furrows on contour curves. Takes but a minute to hook up to Eagle Hitch of Case Tractor, right from the seat and depth can be adjusted from seat. Constant Hydraulic Control lifts, effortlessly. Pivotal Action eliminates side draft, works as beautifully on curves as on straightaway.

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Case Pivotal Action Plows are conservation plows. Not only aiding conservation of soil and water, they help save human energy and time, promoting ever-greater production per man, per hour, per acre, and per machine.

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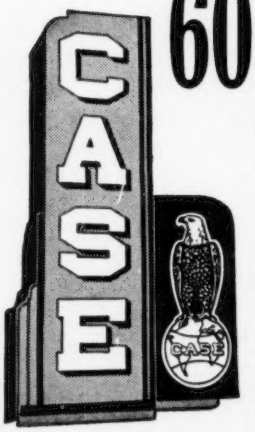

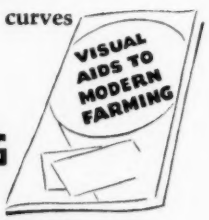

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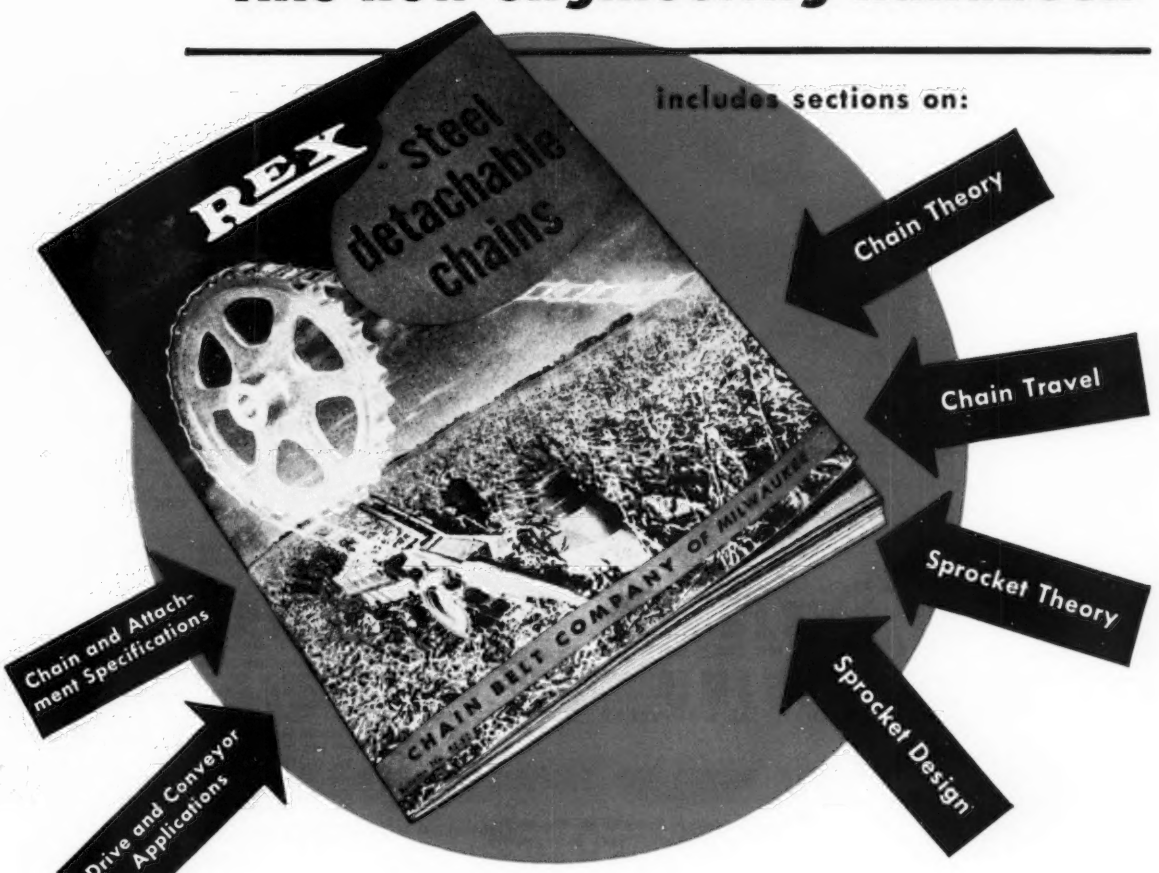

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Established 1920

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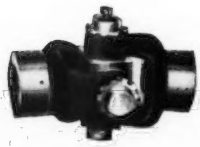

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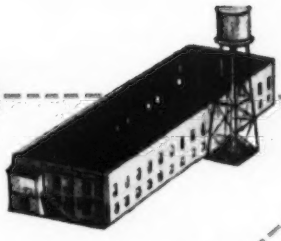

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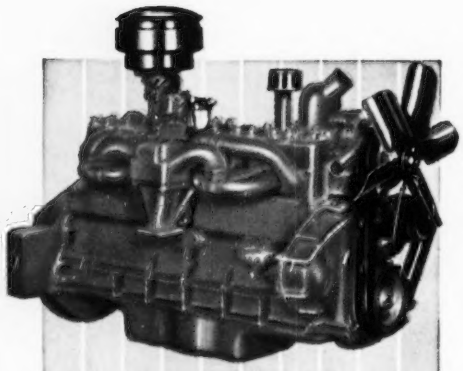
Photo Courtesy Gar Wood Industries, Inc., Findlay Division, Findlay, Ohio

Pedigreed Horsepower digs ditch, carries dirt away, moves ditcher!



Without ever moving from his seat, this operator can dig a ditch eight feet deep and up to twenty-four inches wide. With an individually controlled clutch and brake for each crawler, he can dig straight as an arrow or curved as nicely as you please. With positive-pressure hydraulic controls holding the boom at the desired depth, he can easily undercut pipes or other obstructions, dig right up to foundations. Forward or reverse, the operator can select from a large number of digging speeds . . . going forward, he can dig up to nineteen feet per minute.

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HYDRAULICS FOR MOBILE EQUIPMENT

VOL. 1

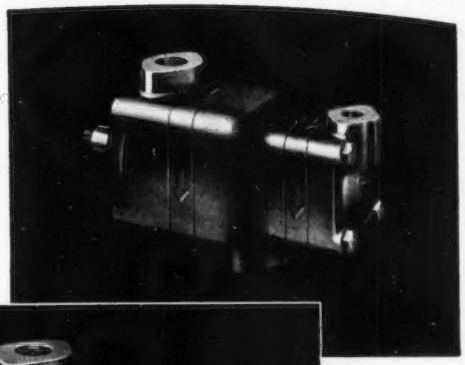
Mobile Equipment News

VICKERS INCORPORATED, DETROIT, MICHIGAN

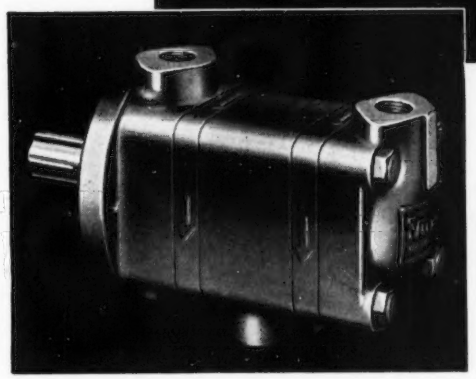
IMPROVES PERFORMANCE • CUTS COSTS

NO. 3

26 MORE VICKERS DOUBLE PUMPS NOW IN PRODUCTION



(Right) Series V-2200 Double Pump in 10 sizes from 3.2 to 32.6 gpm combined delivery.



(Left) Series V-3200 Double Pump in 16 sizes from 11.9 to 51.1 gpm combined delivery.

OFFER MANY REAL BENEFITS WHEN TWO HYDRAULIC CIRCUITS ARE USED ON MOBILE EQUIPMENT

These double pumps are becoming increasingly popular wherever two machine components must operate simultaneously at different speeds and/or operating pressures. They also prevent all possible chance of one operation interfering with another.

TWO PUMPS IN TANDEM

These are essentially two pumps in a single housing and driven by a common shaft. Independent pressure control must be provided as there is a separate pressure outlet for each pump.

LONGER PUMP LIFE RESULTS FROM HYDRAULIC BALANCE

Like Vickers Vane Type Single Pumps, these double pumps have the exclusive Vickers "Hydraulic Balance" that eliminates pressure-induced bearing loads and results in longer pump life.

NO-LOAD STARTING

At rest and normal starting speeds, the sliding vanes are retracted; only after engine fires do vanes extend and pumping begin.

COMPACT AND EASILY INSTALLED

Greater mounting adaptability because of minimum space requirement, 3 mounting styles, optional and independent piping connection positions, shaft drive in either direction.

ASK FOR NEW BULLETIN M-5101

TOP PERFORMANCE THROUGHOUT PUMP LIFE BECAUSE OF AUTOMATIC WEAR COMPENSATION

Radial compensation for normal wear and temperature differentials is provided by the movement of the vanes in the rotor slots. (Wear is minimized because all parts are lubricated by the oil under pressure.)

Axial compensation is by means of a pressure plate held to optimum running clearance by pressure from the system.

Automatic compensation eliminates need for "run in" . . . efficiency is maximum the first time the pump is started. It also assures maximum delivery over a very long life and with wide oil temperature change.

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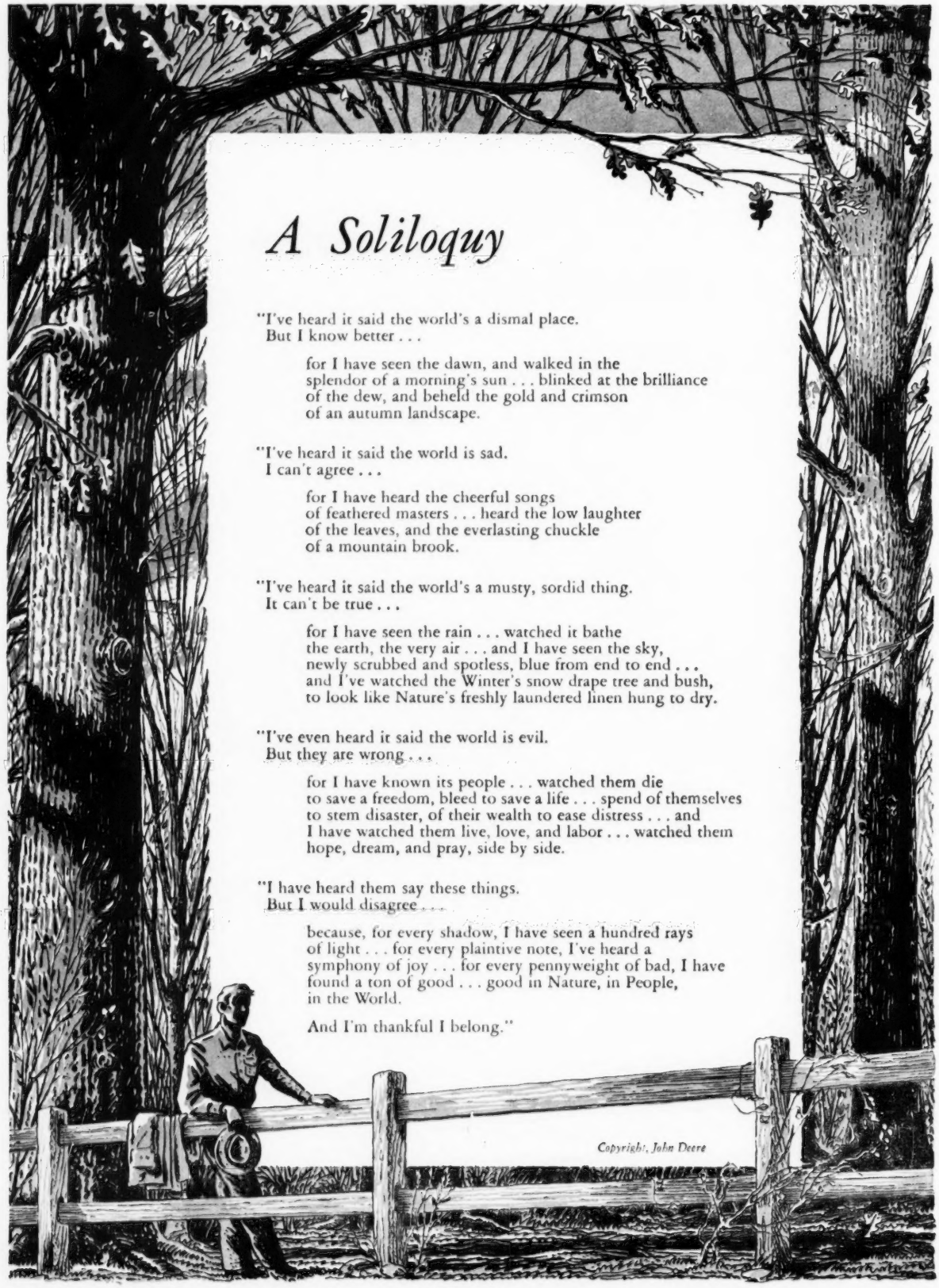
OTHER VICKERS DOUBLE PUMPS FOR MOBILE EQUIPMENT

(Left) Series V-4200 Double Pump in 6 sizes from 30.7 to 70.2 gpm combined delivery.

(Right) Series V-5200 Double Pump in 6 sizes from 48.8 to 89.4 gpm combined delivery.

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



A Soliloquy

"I've heard it said the world's a dismal place.
But I know better . . .

for I have seen the dawn, and walked in the
splendor of a morning's sun . . . blinked at the brilliance
of the dew, and beheld the gold and crimson
of an autumn landscape.

"I've heard it said the world is sad.
I can't agree . . .

for I have heard the cheerful songs
of feathered masters . . . heard the low laughter
of the leaves, and the everlasting chuckle
of a mountain brook.

"I've heard it said the world's a musty, sordid thing.
It can't be true . . .

for I have seen the rain . . . watched it bathe
the earth, the very air . . . and I have seen the sky,
newly scrubbed and spotless, blue from end to end . . .
and I've watched the Winter's snow drape tree and bush,
to look like Nature's freshly laundered linen hung to dry.

"I've even heard it said the world is evil.
But they are wrong . . .

for I have known its people . . . watched them die
to save a freedom, bleed to save a life . . . spend of themselves
to stem disaster, of their wealth to ease distress . . . and
I have watched them live, love, and labor . . . watched them
hope, dream, and pray, side by side.

"I have heard them say these things.
But I would disagree . . .

because, for every shadow, I have seen a hundred rays
of light . . . for every plaintive note, I've heard a
symphony of joy . . . for every pennyweight of bad, I have
found a ton of good . . . good in Nature, in People,
in the World.

And I'm thankful I belong."

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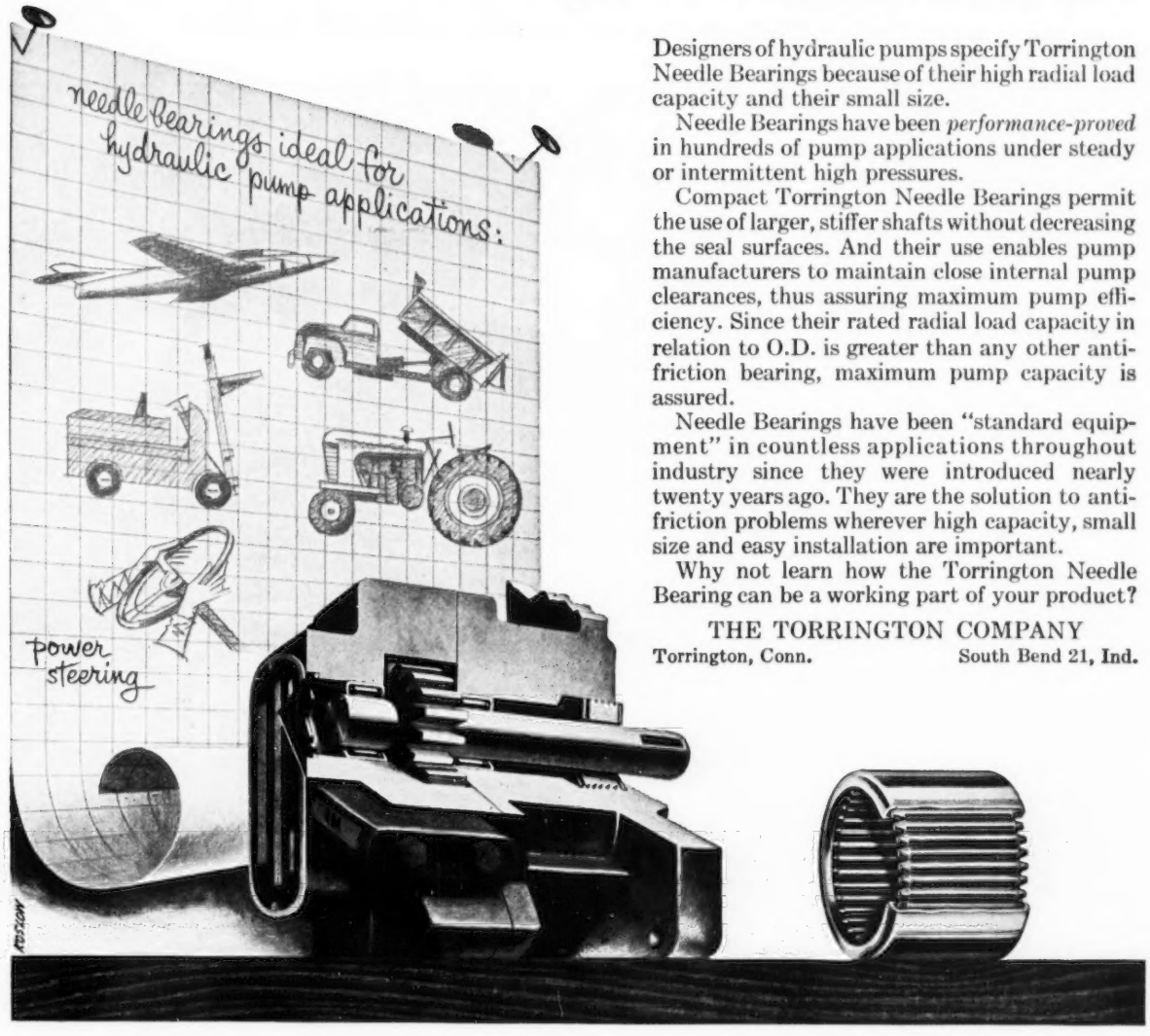
Need a high capacity bearing with small size?

here's how hydraulic pump manufacturers get it with **NEEDLE BEARINGS**



Designers of hydraulic pumps specify Torrington Needle Bearings because of their high radial load capacity and their small size.

Needle Bearings have been *performance-proved* in hundreds of pump applications under steady or intermittent high pressures.

Compact Torrington Needle Bearings permit the use of larger, stiffer shafts without decreasing the seal surfaces. And their use enables pump manufacturers to maintain close internal pump clearances, thus assuring maximum pump efficiency. Since their rated radial load capacity in relation to O.D. is greater than any other antifriction bearing, maximum pump capacity is assured.

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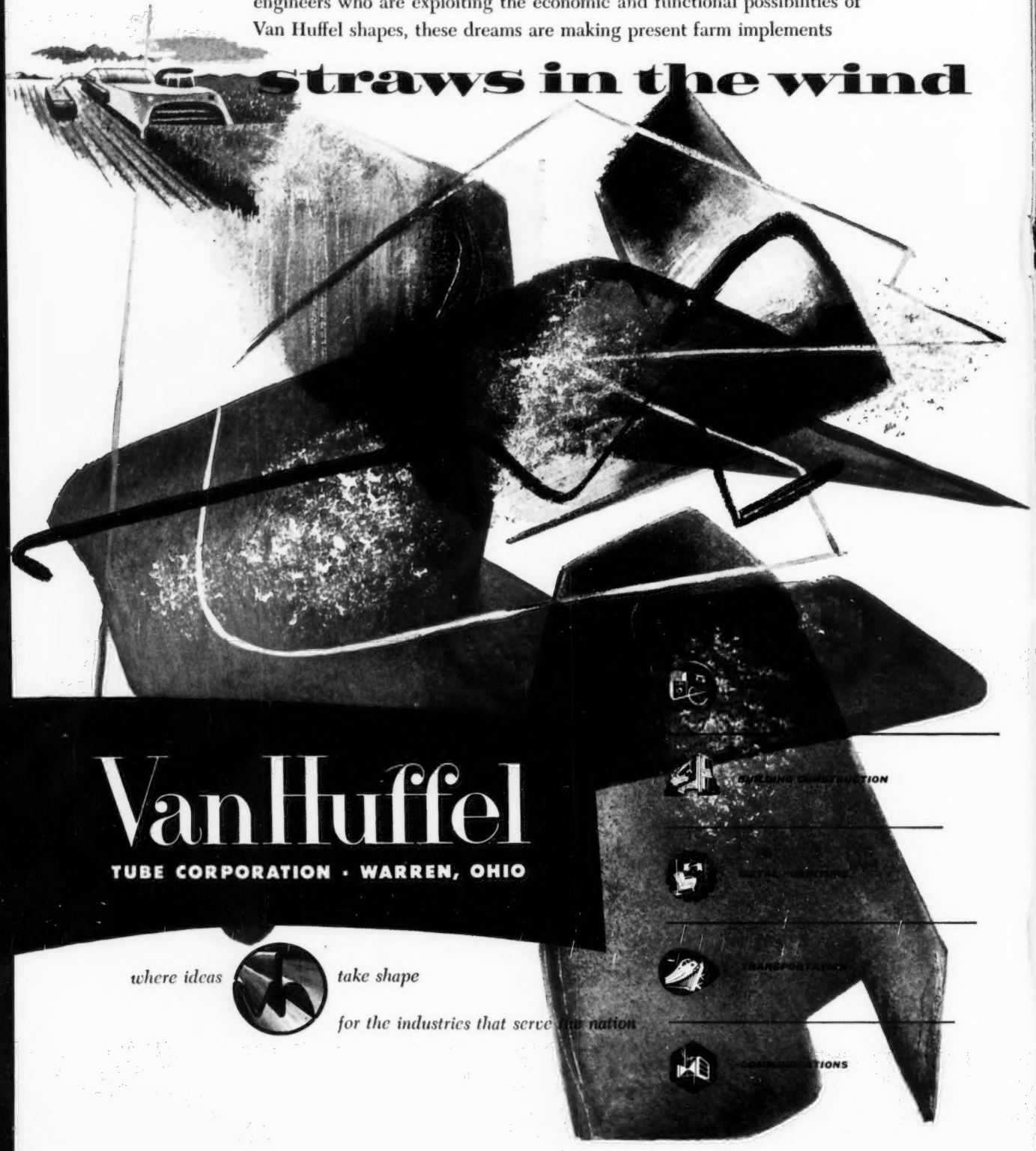
Only an imaginative "let's look ahead" attitude toward new materials and production techniques made possible today's amazing farming methods and equipment. For example, take some of the "impossible" shapes we cold form daily from all kinds of metals, in any lengths and for an ever growing list of farm applications. Yesterday, these applications were but drawing board dreams. Today, thanks to alert design engineers who are exploiting the economic and functional possibilities of Van Huffel shapes, these dreams are making present farm implements

straws in the wind



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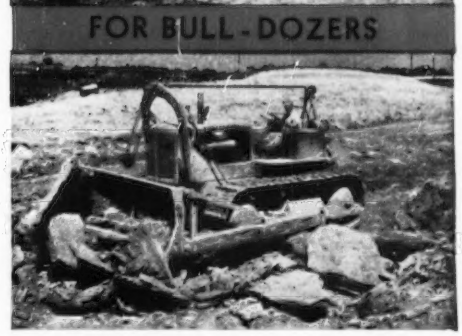

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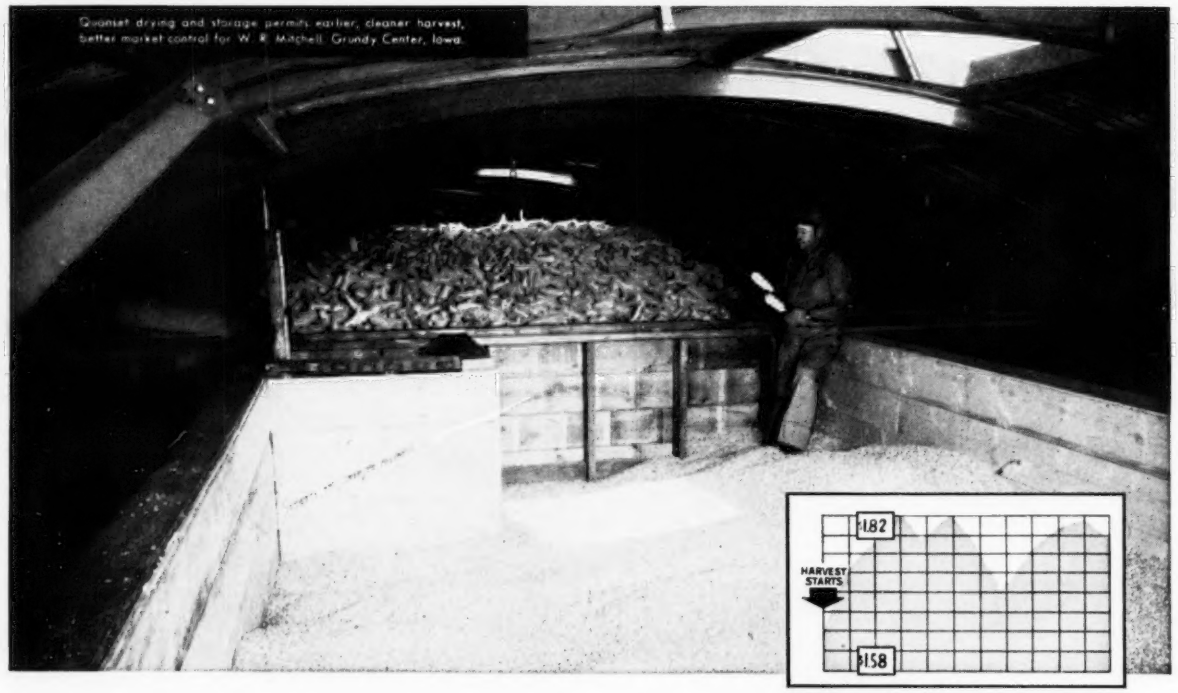


Quonset drying and storage permits earlier, cleaner harvest, better market control for W. R. Mitchell, Grundy Center, Iowa.

Avoid harvest time glut . . . get more for your grain with on-the-farm Quonset storage. Chart shows monthly corn prices for the 1951 crop year.

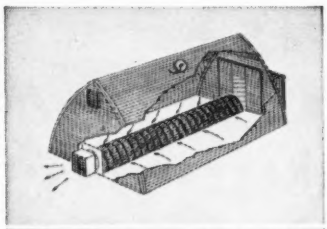
Quonset owner leads the way to greater grain profits

W. R. Mitchell, tenant farmer, of Grundy Center, Iowa, views with pride his 1952 corn crop—the first corn picked in Grundy County last year.

Because Mr. Mitchell used a Quonset combination ear corn drying unit and granary, he was able to begin picking his corn on September 27—at 30% moisture content—up to 30 days before his neighbors. Mr. Mitchell reports his picker left less corn in the field, his corn borer loss was minimized and he no longer worries about a wet fall when the corn is slow to field-dry.

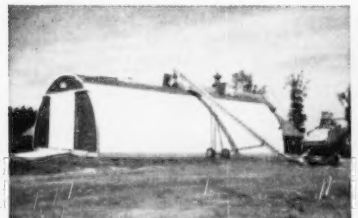
This Quonset 32 x 60 dried 5,500 bushels of ear corn and its smaller bins held up to 4,000 bushels of other grains. The farm owner purchased this size because it provides ample separate bins for his own share of the crop, as well as Mr. Mitchell's.

Thousands of farmers have found that grain can be safely stored right on their own farms . . . held until market prices are right or the grain is needed for feeding. Quonsets are available for any capacity—1005 to 50,000 bushels. They are easy to finance on the Quonset Purchase Plan or through CCC Storage Facility Loans.



This Quonset 16 Granary, complete with fan-and-tunnel "package," lets you dry and hold your grain.

Consult your authorized Quonset dealer . . . a specialist in farm service buildings, or write us direct for complete information on the Quonset best suited to your operation.



Good-looking, durable and easy to maintain. That's the Quonset . . . all-purpose farm production tool.

"My farm machinery is easier to service," says Endren P. Johnson, Huxley, Iowa, of his Quonset.

Beef barn owned by W. A. Allely of Montezuma, Iowa, is a time-saving, labor-saving Quonset 40 x 60.

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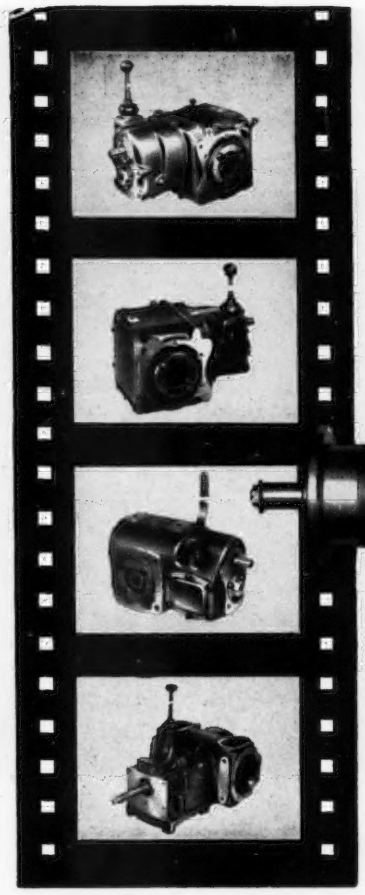

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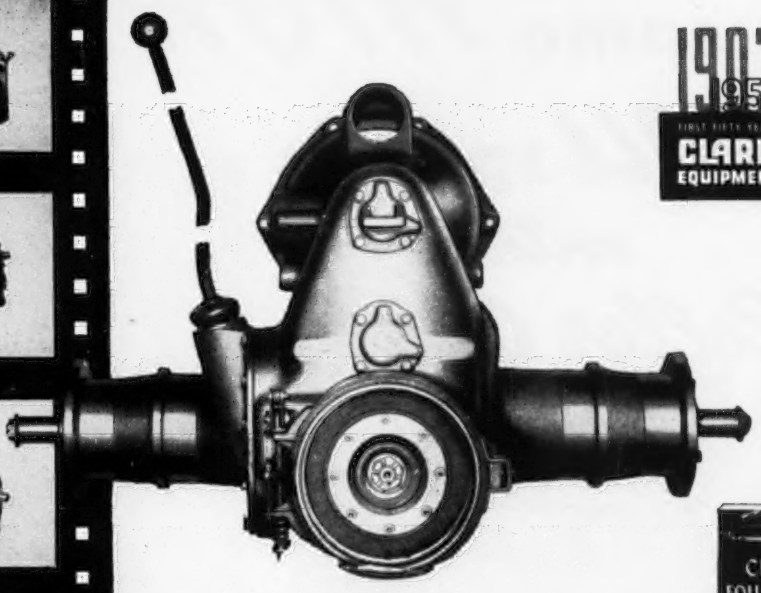

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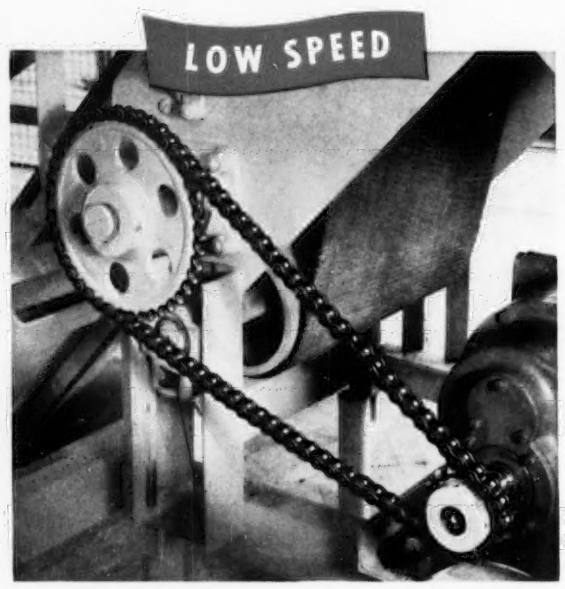

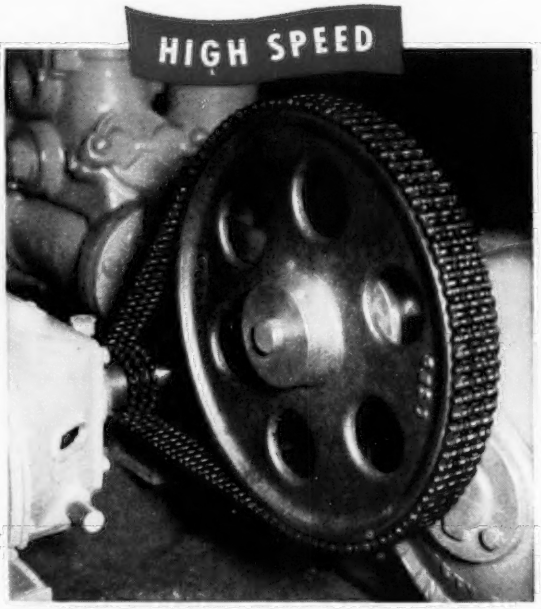

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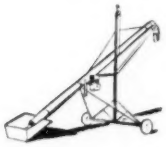

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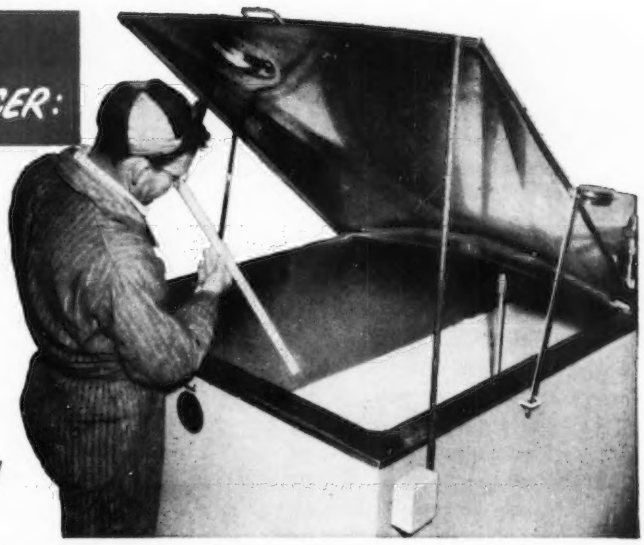
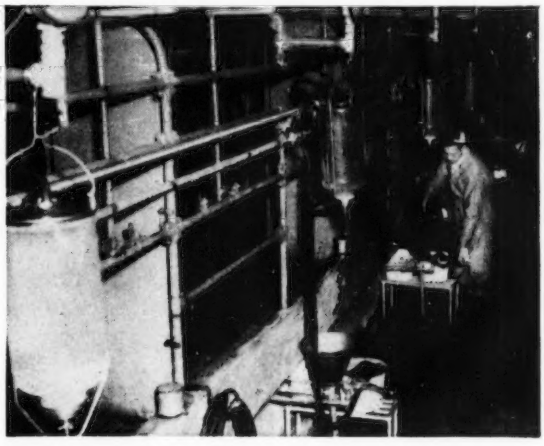


—**OLIVER KEITH,** Manager, Rockacres Farm, Lewisburg, W. Va.



OLIVER KEITH, manager of Rockacres Farm, checks the quantity of milk in the 500-gallon storage tank which is lined with Stainless Steel. Pick-ups are made every other day.

MILKING PARLOR at Rockacres Farm relies heavily on Stainless Steel, too. Milk enters Stainless teat cups and passes through Stainless pipe to the Stainless Steel cooling and holding tank. Sixty-five cows are now milked daily, and the herd is being greatly enlarged. The increase in herd size is made possible through the use of these modern methods of milk production.

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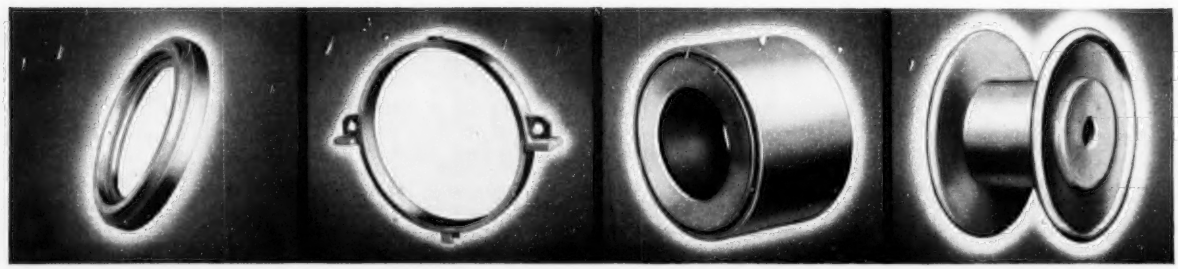

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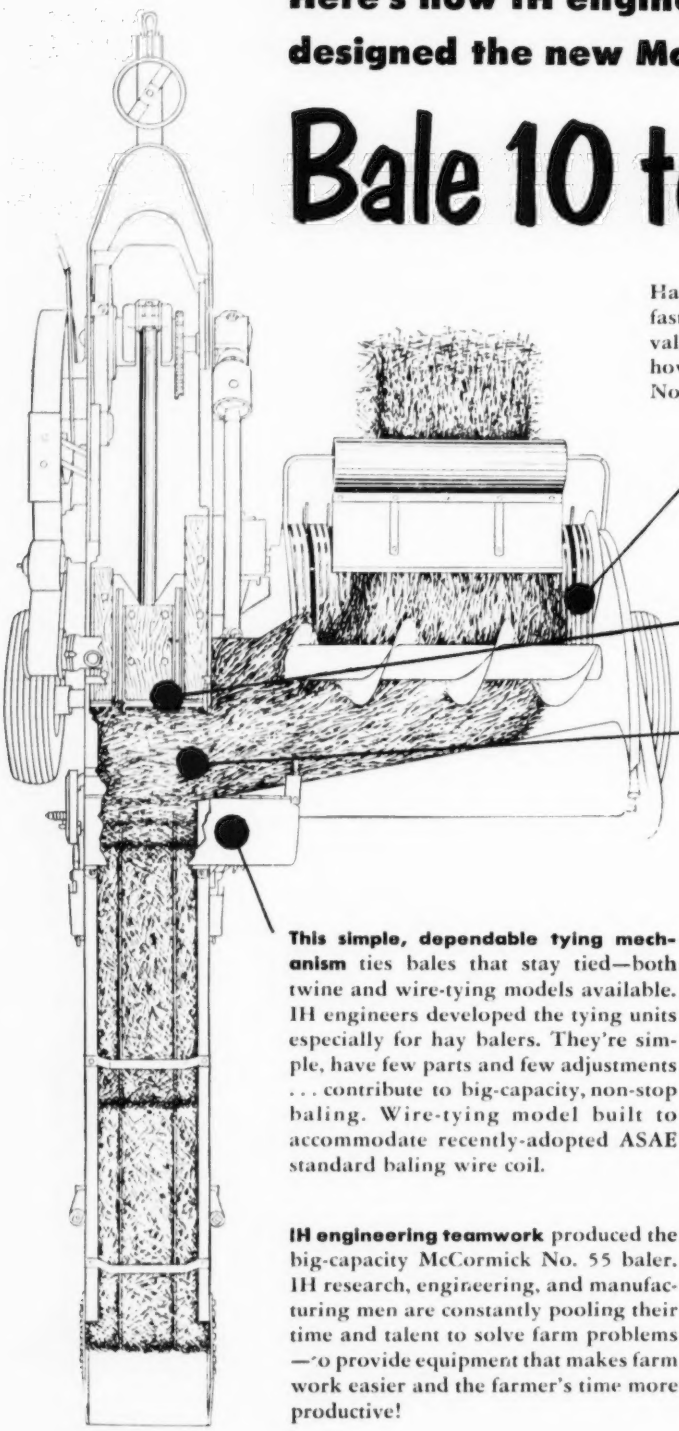

Hay growers want a big-capacity baler to bale hay fast—to retain feed-rich leaves for maximum feeding value. They want compact, easy-to-haul bales. Here's how IH engineers designed the new McCormick No. 55 baler to meet those demands.

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IH engineering teamwork produced the big-capacity McCormick No. 55 baler. IH research, engineering, and manufacturing men are constantly pooling their time and talent to solve farm problems—to provide equipment that makes farm work easier and the farmer's time more productive!

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AGRICULTURAL ENGINEERING

VOL. 34 MAY, 1953 NO. 5

Machinery Aspects of Land Drainage

Irwin L. Saveson
MEMBER ASAE

IT IS an accepted fact that the advancement of any industry is directly related to the applicable machines available for doing the work. Agriculture is no exception, especially in the field of land drainage. It is the intent of this paper to review the land drainage problem in light of the machinery aspect, since the advancement and maintenance of drainage is dependent on machines applicable to the work required.

A number of factors influence the operating of machines on drainage work. The period of operation is limited due to the land being occupied by crops and periods of inclement weather. This means the machines must be able to operate at maximum capacity during the available work period. Machines must be able to work in earth of various textures and degrees of moisture content and under varying degrees of trashiness. They also must be adaptable to the task at hand to produce quality work at the lowest possible cost.

Land drainage work may be considered under two categories — outlet drains and field drains.

OUTLET DRAINS

Outlet drainage work was the first drainage work to be given major consideration, since it is impossible to secure good land drainage without adequate outlets. Outlet drainage works consist mainly of excavated channels ranging in size from the 4-ft minimum ditch to large, navigable channels. Due to the magnitude and extent of outlet systems, considerable research has been done on this phase of drainage and considerable information is available for the drainage engineer. Likewise, considerable machinery development has taken place in this phase of the work. Outlet drainage has been a machine operation for a considerable length of time and the most applicable machine for doing this work is well defined.

The dragline has been used for excavating outlet drainage channels for a number of years. It will probably be the most applicable machine for some time, due to its ability to remain on solid footing away from the channel to be excavated. Many refinements have been made in draglines in the last few years, one being that sections fabricated from steel plates by welding have replaced many of the heavy castings which makes for a lighter and sturdier machine.

The lighter machines are especially desirable because of the reduced load limits of a number of state highways over which the machines are moved to the work location. The lighter machines in many instances can work without the mats required by the older, heavier machines.

The air, hydraulic, and other activated controls with which the later machines are equipped lessen operator fatigue which makes for better control of the machine and a larger output of work. More anti-friction bearings are gradually being incorporated into the machines each year which makes for more efficient power consumption.

The clearing of ditches prior to rehabilitation still constitutes a problem. In most instances it is a hand-labor job. Machines or attachments for ditch clearing have not been developed to a point where they are offered by manufacturers. A few attachments have been improvised by contractors. A Louisiana contractor replaced his bulldozer

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952 as a contribution of the Soil and Water division.

The author—IRWIN L. SAVESON—drainage engineer (BPISAE), U.S. Department of Agriculture.

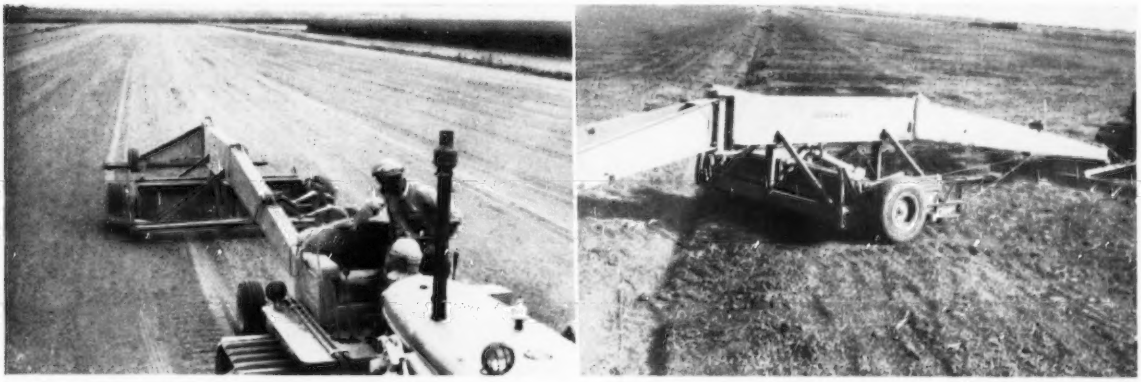

Fig. 1 *(Left)* Grading turtlebacking of sugar-cane cuts to improve surface drainage. Smoothing fields with Caterpillar D-6 tractor and Eversman land leveler after grading • *(Right)* This picture shows special work with an Eversman land leveler to slope the bank around a sugar-cane ditch in an area which is being put into permanent pasture. The leveler is operating crosswise of the cuts at an angle. It was found that the blade would cut banks at a slight angle rather than going perpendicular to the ditch

blade and arms with an A-frame of approximately 20 ft in length. A blade or shank of approximately 30 in in length was mounted at the front of the frame perpendicularly. A wide flat point was mounted on the end of the shank. This device was originally used in cutting the brace roots of trees in clearing land. The long A-frame was used as a push pole in felling the trees after the brace roots were cut. The 20-ft A-frame gave a higher point of contact on the tree than other implements, and thus greater leverage.

This attachment has been used on some ditch-clearing work. The point is placed under small trees and the tree pulled. The brace roots are cut on larger trees and the tree pushed down. The shank of the attachment is used as a hook to pull the tree out and away from the ditch. In addition to machines for ditch clearing, men engaged in drainage work have pointed out the need for a light mobile machine for outlet-channel maintenance, to remove bars and shoals.

FIELD DRAINAGE

Field drainage of agricultural land is a complex problem and the information available for the engineer and the farmer is less than the information for outlet channels. Likewise, the machinery development and adaptation work is not as extensive. The problem is complex due to the interrelated factors of hydrology, hydraulics, soil science and climatology and is a challenge to the agricultural engineer. Field drainage of agricultural land consists of two types: profile drainage, often referred to as under drainage, and surface drainage.

Profile Drainage. Tile drainage systems are in the profile drainage category. Probably more work has been done in this phase of field drainage, from both the research and machinery development angles. The installation of tile drains probably is the oldest machine job in field drainage. Like the dragline, the tile trencher has had many refinements such as welded frames, anti-friction bearings, and better controls. Several attempts have been made in the past to develop an attachment on the tile trencher to lay the tile, but so far they have not been successful to a point where manufacturers have them in production. It is the opinion of the author that, if an attachment can be developed to lay and blind the tile, it would be a worthwhile addition.

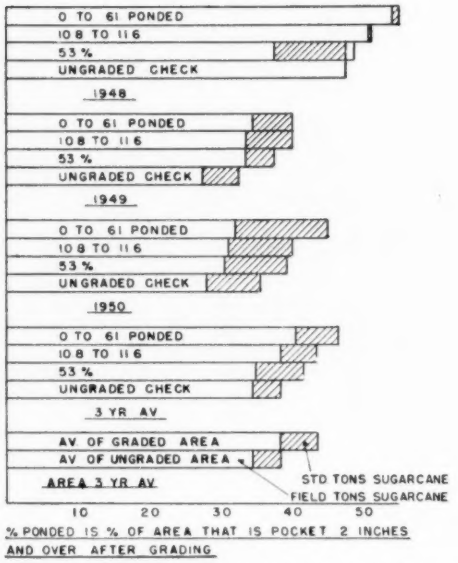

Fig. 2 This graph shows how precision in grading affects yields. The results are from Westover test area at Port Allen, La., for 1948, 1949, and 1950

Surface Drainage. It is to this phase of the drainage work that it seems logical to devote the major part of this paper.

The importance of surface drainage is shown in the agriculture of the South which is in the higher rainfall belt of the country. The extent and magnitude of field ditch systems signify the importance of surface drainage. In the Mississippi River delta section of Louisiana, the sugar-cane area has approximately one mile of ditch to every 20 acres of land and in the cotton area one mile of ditch to every 50 acres of land. The importance of surface drainage is also being indicated in other parts of the country, especially in the tighter soils.

More emphasis is being placed on surface drainage, both in the field of drainage research and machine application for doing the work. Three conditions are responsible for the increased concentration of effort in the field of surface drainage, as follows:

1 A century or more of agricultural production has gradually changed the land pattern and this has impaired

Fig. 3 *(Left)* This picture shows grading of sugar-cane cuts to improve surface drainage and hauling earth to fill low areas from spoil from canal excavation • *(Right)* Grading and crowning sugar-cane cuts with Caterpillar motor grader to improve drainage

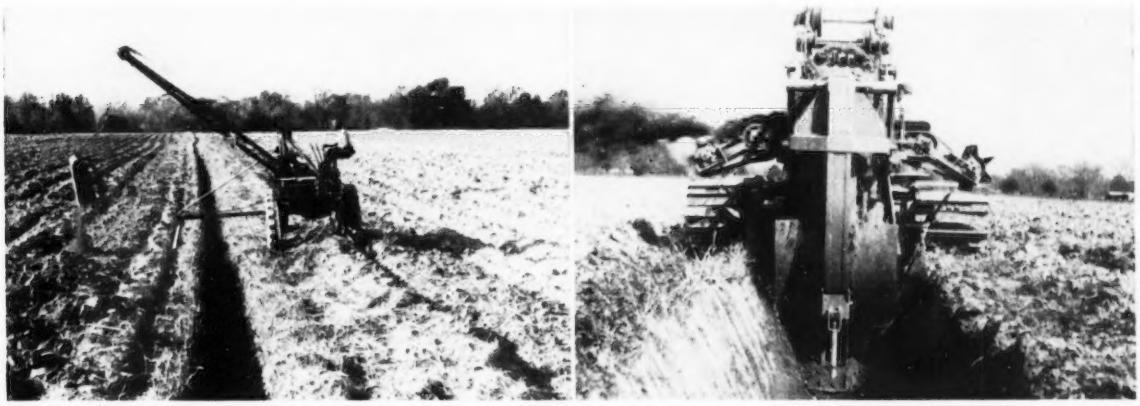

Fig. 4 (*Left*) This picture shows a Castagnos cane loader equipped for ditching using side arm and sloping bucket, with bucket excavating • (*Right*) This is a rear view of an experimental ditcher for cutting sugar-cane lateral ditches. The machine is a specially equipped Buckeye 306 trencher. The special equipment consists of an extended and widened track and powered side cutters for sloping the ditch and a high-speed impeller for cutting the earth

the surface drainage which is taking its toll in crop production. A factor contributing to this changing land pattern is the direction of operation of field equipment. Farm implements leave scars and depressions which impound water. In many instances the breaking and cultivating of farm land is in the same direction season after season, leaving holes where the implements enter the ground and piling up earth where they leave the ground. The result is obvious. This is especially true in southern agriculture where crops are grown on bedded rows and the land is broken by reversing the rows. Many of the surface-drainage problems of farm lands are man-made by not removing the implement scars. The inadequate disposition of spoil from ditch excavation, both outlet and field drains, has left many barriers and depressions which interfere with the surface drainage. Excess rainfall is impounded. The water impounded becomes stagnant and the only natural source of removal is by infiltration into the soil or by evaporation into the atmosphere. A similar condition exists in the alluvial areas due to flood waters which have left their scars in the form of sloughs and depressions, accompanied by an uneven deposition of silt.

2 Over the last ten years, there has been an increasing demand for agricultural products due to the national defense effort and an increase in population. This demand for agricultural products has created a need for maximum production of tillable land. The increase in livestock numbers have brought a demand for better pastures. This demand has emphasized the need for surface drainage of pasture land. Depressed areas that impound excessive rainfall do not produce grass and in addition harbor animal parasites.

3 The shortage of labor for cleaning and maintaining field drains became an acute problem during World War II. Many farm workers went into military service or migrated into the cities where they worked in defense plants. This condition brought about a demand for machines to clean and maintain field drains.

LAND GRADING

The grading of farm land is a comparatively new approach to solving the field-drainage problem. This approach is based on the assumption that by improving the surface field drainage of land the excess rainfall will be removed before it becomes a load or overload of the natural or artificial soil profile drainage.

One of the first concentrated investigations of the feasibility of grading land for drainage grew out of the field-drainage problem of the Louisiana sugar-cane area. This area is located in the southern part of Louisiana where the average rainfall is approximately 60 in per year, and where a number of soils are of low permeability. This investigation is a joint undertaking of the U.S. Soil Conservation Service (Research) and the Louisiana Agricultural Experiment Station. The joint research undertakings have been concentrated on two phases of surface drainage since 1944 — the grading of land for drainage and the construction of lateral ditches.

Since the grading of land for drainage is in its infancy, I would like to point out some of the findings of this project as it relates to the machinery aspect of drainage.

The first work of the project concentrated on crowning sugar cane cuts* similar to a highway and is often spoken of as turtlebacking. The cut sloped from the center to each lateral ditch. The primary objective was to hasten the removal of the water from the middles and lessen the depth of quarter drains required. The need for precision grading was soon evident. One test area consisted of twelve cuts with practically the same amount of crown. The precision of grading varied considerably between cuts. The area was planted to CP-36-13, a cane which is very intolerant of wet conditions. Every ponded area or pocket was in evidence during the growing season. The cane was less vigorous and in some cases the stand was sparse.

The yield records of this area for 1950 further exemplified the condition. After the harvest the project ran a number of levels over this area. The accompanying graph shows yields plotted against the percentage of ponded area, 2 in or over. Ponded or pocketed areas, 2 in or over, are areas that have earth, 2 in or higher, between them and the lateral ditches. It will be noted that both the yield of cane and the yield of sugar decreases as pondage increases.

* A "cut" is the area between two lateral ditches and the two access roads, known as headlands, approximately 100 to 250 ft wide by 1000 ft long.

It is almost inconceivable that ponding of only 2 in with a crop grown on 18-in rows should have such an effect on yields. However, the graph very definitely shows that precision in grading is highly important. Grading work, therefore, should be done with as much precision as possible and ponded areas or pockets should be kept to a minimum. This requires machines that will give the best grading job possible.

It is further believed that there is a definite relationship between the precision of grading and the proper amount of slope. It is thought that the slope can be lessened with increased precision in grading because steeper slopes tend to offset the retention of water in pockets. A barrier will cause a larger pond on a flat slope than on a steep one. Test areas which should give more definite information covering this phase are under way; however, on a precision-graded cut a slope of 3 in per 100 ft will probably be ample. This gentle slope indicates the need for machines capable of making light cuts and fills.

The ideal moisture content for grading work is the moisture content at which land is generally plowed. If land is graded when wet or muddy, the yield will be reduced. This is indicated by one test area where the yield was reduced by half the first year, and only salvage cane was harvested the second year. This indicates the need for machines which will do the least amount of packing of the soil.

The yield records of 105 acres of average sugar-cane land for 1946 to 1950 show an increase of 5.81 standard tons of cane per acre. The average price of sugar cane over this period was $7.82 per ton. This is a monetary value of $45.43 per acre per year. From this, it can be concluded that an expenditure of $45 per acre for grading sugar-cane land would be liquidated the first year. The increase in the crop the following year would be a net profit. This would indicate that there is a substantial margin of return for doing the work.

The grading of typical average sugar-cane land requires from 4½ to 5½ hrs per acre. Areas that have been subjected to flood-water influence may require as high as 10 hr per acre. Research information is not available for other localities and crops.

LAND-GRADING EQUIPMENT

A wide choice of equipment is available for landowners to use in grading land, such as bulldozers, plows, graders, scrapers, terracers, drags and land levelers. Each type of equipment has its advantages and limitations. The success of their use depends on the method used and the skill of the operator. Time does not permit going into each type of equipment and its method of use. In general, combinations of equipment are desirable to expedite the work. The most usable combination indicated by the project's work is approximately 65-hp (drawbar) track-type tractor, a 4 or 6-cu yd wheel scraper (either 2 or 4-wheel), and a floating-type land leveler of approximately 50-ft length, hydraulically controlled and hinged in the center. This combination of equipment is probably the most foolproof of any tested, and the skill required for its operation is much less than for the other types.

A number of problems are in evidence with the machinery aspect of the work. The majority of our land-grading equipment, referring specifically to land levelers, was developed for the irrigated sections of the country. When it is used in the humid sections, it is required to work under varying degrees of soil moisture and trashiness which oftentimes requires modification and reinforcing. Contractors' equipment such as motor graders and scrapers pack the earth and require ripping before planting. The land-grading equipment from the irrigated section is new to the farmer of the humid area and much educational work is needed to familiarize him with its operation and limitations.

LATERAL DITCHES

Field observations indicate that lateral ditches are effective in lowering the water table in periods of excessive rainfall, and from the experience of the project the most applicable depth is between 30 and 36 in. The lateral ditches seem to be more stable at this depth. Since the deep drainage canals soon pull the water table below the lateral ditches, the drawdown becomes a less important factor in considering lateral ditch spacing. The item of ditch spacing is governed more by the width of cut that is feasible and practicable to grade than by the lateral-ditch drawdown feature. Depending on the condition of the land and the presence of perched water table or river seepage, the practical width of cut (and in turn the ditch spacing) for mixed land is 240 ft and for blackland 180 ft.

The straddle dragline and the sloping side bucket is probably the most usable machine on the market for the large plantations since the dragline can be used on a portable crane for transferring sugar cane to trucks and railroad cars. The ditching attachment for tractors and cane loaders are the most usable for the small plantation. There is still need for a ditcher which will completely disperse the spoil. This is not only true for sugar-cane ditches but generally wherever field ditches are used. The specially equipped Buckeye 306 experimental wheel trencher was a step in this direction, but the present emergency has delayed its development.

The work carried on jointly by the Soil Conservation Service (Research) and the Louisiana Agricultural Experiment Station has made substantial progress in solving the problem of surface drainage created by unusual climatic and soil conditions in Louisiana. This work has also spread to other sections of the country. Continued research will, without question, develop many refinements, including the adaptation of new machines and methods for more economical ways of expediting and accomplishing the work.

The Professional Engineer

THE future of engineering as a profession in North America depends upon the ability of the engineering colleges to advance their education to new levels of professional achievement. The incentive for both students of engineering and the engineering colleges, however, is in the hands of those who direct the progress of the graduates after they leave the college halls.

The answer to either the students of the engineering colleges or to the man who plans to grow is not unionism. The reward for which the professional engineer strives is a composite of full recognition and appreciation for the manpower product of the engineering colleges by those who employ, advise and direct. The compensation should be commensurate with the abilities and contributions of each individual of the profession.—W. R. Woolrich in *American Engineer* for April, 1953.

A Recording Torquemeter

I. F. Reed and M. O. Berry
MEMBER ASAE ASSOC. MEMBER ASAE

THE recording torquemeter described in this article was developed to fill the need at the USDA Tillage Machinery Laboratory at Auburn, Ala., for a simple, accurate, inexpensive device for measuring the power requirements for rotary-type tillage tools. Available torquemeters observed or those discussed in the references appended to this article failed to meet one or more of these requirements. Some were costly, some were complicated, some were too cumbersome to handle, and some had several of these shortcomings.

The USDA torquemeter, simply explained, transforms rotation force, or torque, into a force parallel to the drive shaft where it is resisted by liquid-filled bellows. These bellows are connected to a gage designed and calibrated to indicate or record either torque or power. The assembled unit is shown in Fig. 1. The box is 11 x 11 x 6¾ in. It weighs approximately 150 lb and has a rated capacity of approximately 4100 in-lb torque using a 4-in built-in torque arm and three hydraulic cells, each having a maximum rated capacity of 373 lb. This gives a rated capacity of about 6.4 hp at 100 rpm and 128 hp at 2000 rpm. The capacity and sensitivity of the unit can be changed by selection of the proper hydraulic cells and gage units.

A partially exploded view of the torquemeter is shown in Fig. 2 and the relationship of the parts shown in the diagram, Fig. 3. The spider marked *C* in the figures is attached rigidly to input shaft *A*. It rotates transmission plate *D* by contact with the spider rollers *J*. The 45-deg inclined blocks *G* on plate *D* contact the rollers *F* on plate *E* which is rigidly attached to output shaft *B*. Since the force required to turn output plate *E* is transmitted to it through the inclined blocks *G* on transmission plate *D*, a force equal to the torque is set up parallel to the center line of shafts *A* and *B*. This force is transmitted through a thrust bearing to the non-rotating plate *H* which operates against the three hydraulic bellows. The pressure set up in these bellows or cell units may be shown on an indicating gage or recorded as desired. Horsepower can be determined if the chart and chart drive are arranged to enable determining revolutions for a unit of time or calibrated to give power if the chart is driven from the torquemeter shaft and time intervals are marked on it. A reduced section of shaft *B* equipped with suitable bearings fits into a recess in shaft *A*, thus keeping them in alignment.

The USDA torquemeter has ample capacity for measuring the power requirements of power-take-off-driven rotary tillage tools, can be mounted in practically any position, is portable, measures only torque output, is accurate, and is simple both in construction and operation. The design, capacity, and sensitivity are flexible and can be fitted to almost any requirement.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors — I. F. REED and M. O. BERRY — are, respectively, senior agricultural engineer and (former) associate agricultural engineer, Division of Farm Machinery, Tillage Machinery Laboratory, U.S. Department of Agriculture

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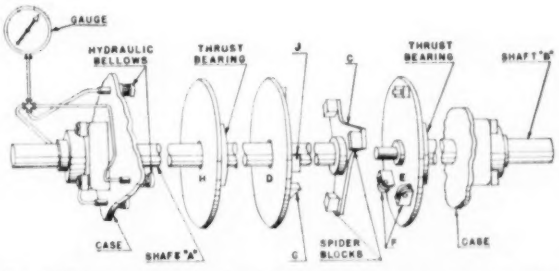
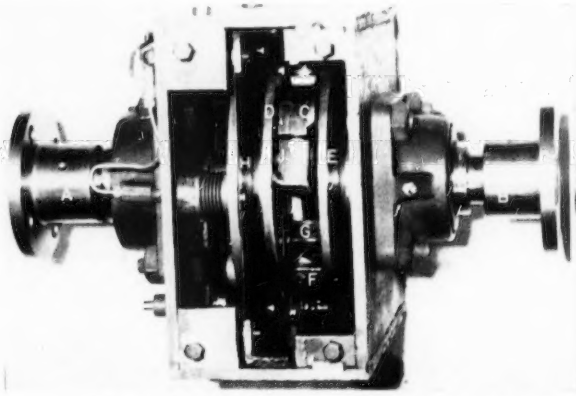


Fig. 3 Diagrammatic sketch of USDA torquemeter showing relationship of working parts



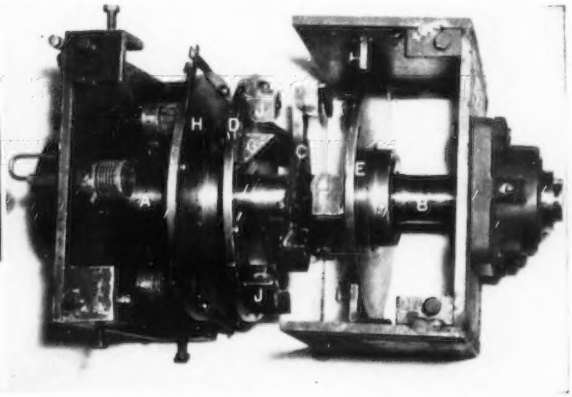


Fig 1 (*Left*) USDA torquemeter with top lever plate removed • Fig. 2 (*Right*) Partially exploded view of USDA torquemeter showing parts

Speed Fluctuation in Multijoint Power Lines

J. H. Berry and C. L. Callum

DUE to the increasing use of power-take-off-driven machines, and also the increasing power requirements of such machines, much attention has recently been given to power shafts and universal joints. The aim of this paper is to present useful information relating to the elimination of speed fluctuations in multijoint power lines. In a paper published in AGRICULTURAL ENGINEERING (vol. 33, January, 1952), F. M. Potgieter gave examples of the application of universal joints of the Hooke or Cardon type to farm machines. The theory of a single joint has been known for many years, and the sources of the mathematics involved are referred to in the Potgieter paper. Since this information is also available in standard textbooks on mechanics, it will be assumed that readers are already familiar with it. Thus, this paper will proceed to further theoretical considerations of the Hooke joint accepting the following well-known formulas:

$$\tan Y_1 = \tan Y_2 / \cos A$$

where Y_1 = angular displacement of driving shaft

Y_2 = angular displacement of driven shaft

A = angle between the two shafts.

$$\text{Then } Y_2 = \text{Tan}^{-1} [(\tan Y_1)\ (\cos A)] \quad . \quad . \quad . \quad . \quad . \quad [1]$$

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors—J. H. BERRY and C. L. CALLUM—are, respectively, senior test engineer in charge of testing and research section, John Deere Ottumwa Works, and lecturer in agricultural engineering, North of Scotland College of Agriculture (Aberdeen).

AUTHORS' NOTE: The authors gratefully acknowledge the assistance of Wm. E. Gustin and Merlin Hansen, engineering department, John Deere Waterloo Tractor Works, in accumulating the laboratory test data for this paper.

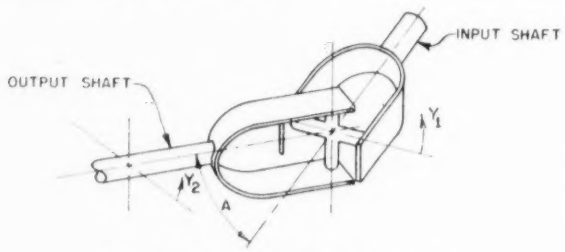


Fig. 1 Angles used in defining yoke rotation

Fig. 2 Nominal lead or lag curve for single joint

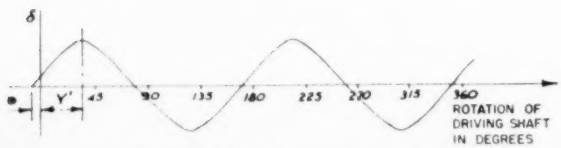


Fig. 3 True lead or lag curve for single joint

NOTE: This formula applies only when Y_1 is measured from the original location of the driving portion of the yoke cross as shown in Fig. 1.

It will be seen from this that the driven shaft does not rotate with constant angular velocity but leads or lags behind the driving shaft by a constantly varying angle δ. If δ is plotted against the angle of rotation of the driving shaft, a curve of sinusoidol form is obtained as shown in Fig. 2.

This is a double-frequency wave, i.e., two cycles occur in one revolution of the shafts. The magnitude, or the maximum lead or lag, is dependent solely upon the angle between the two shafts.

Though the wave in Fig. 2 would indicate that the maximum lead occurs at angles of driving shaft rotation of 45 deg, 225 deg, 405 deg, etc., and the maximum lag at 135 deg, 315 deg, 495 deg, etc., actually they do not. This slight inaccuracy is due to the fact that equation [1] is a special-condition equation applying only when the joint starts from the position shown rather than the general equation which would apply for any starting position and any shaft angle. However, it is comparatively simple to determine the true angles at which the maximum leads and lags occur. The equation given for this is:

$$Y'' = \tan^{-1} [\pm (\cos A)^{1/2}] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

where Y'' = shaft angles at which the maximum leads and lags occur

A = angle between the two shafts.

Again conditions are dependent solely upon the angle between the two shafts. The true wave for a single joint is shown in Fig. 3.

On the curve the actual phase-shift angle of the wave is shown as θ, where

$$\theta = 45 \text{ deg} - Y'' \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

From these facts it is obvious that the driven shaft cannot rotate at constant angular velocity whenever there is any angularity between the shafts. In many applications it is possible to use two joints, such that the effects of the first

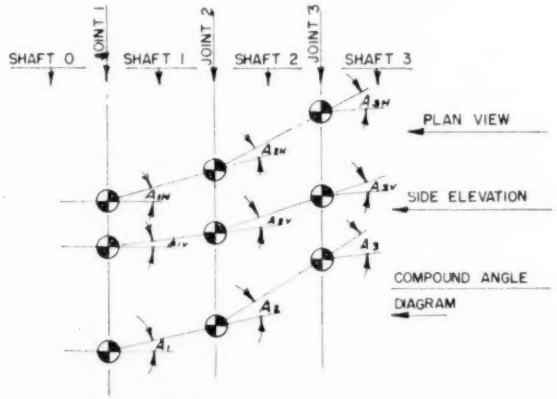


Fig. 4 Shaft angles in three-joint power line

joint will be nullified by equal and opposite effects in the second joint. These conditions occur when the angle between the driving and intermediate shafts is equal to the angle between the intermediate and driven shafts. This fact is known to all designers and most operators. However, it will be shown that this is just one special case of the general theory. If the shafts connecting the joints do not lie in the same plane, a correction can be made to obtain constant angular velocity of the driven shaft by turning the second joint yoke through the angle between the planes of the shafts as reported by Potgieter.

Whenever it has been necessary to use more than two joints in any machine, difficulty has generally arisen in producing uniform angular velocity in the final driven shaft. The problem is analyzed below, and a method evolved whereby the angular lead or lag of each shaft in a power line using any number of universal joints may be calculated and controlled quite simply.

Consider a power line containing three universal joints as in Fig. 4, an arrangement which occurs frequently in the farm machinery industry. The joint yoke angles are first set so that the effect of the shafts being in different planes is corrected. From here on the problem becomes one in which all shafts are lying in one plane and the procedure is given as follows:

A_{1H}, A_{2H}, A_{3H}=angles between shafts 0 and 1, 1 and 2, 2 and 3, respectively, in a vertical plane

A_{1V}, A_{2V}, A_{3V}=angles between shafts 0 and 1, 1 and 2, 2 and 3, respectively, in a horizontal plane

A_1, A_2, A_3=compound angles between shafts 0 and 1, 1 and 2, 2 and 3, respectively.

Compound shaft angles are determined from the shaft angles in the horizontal and vertical planes, viz.,

$$A_1=\tan^{-1}\left[(\tan A_{1V})^2+(\tan A_{1H})^2\right]^{1/2}$$

If each joint is considered separately, curves representing the lead and lag of each driven shaft can be constructed, since the actual angle between each pair of shafts is known. These curves are shown in Fig. 5.

Let us assume that the driving shaft, which would normally be the tractor power-take-off shaft, is rotating with constant angular velocity. The curves for shafts 1, 2, and 3 are double-frequency functions and may be represented by the following equations:

$$\delta_1=\Delta_1 \sin 2(\omega t+\theta_1) \quad [4]$$

$$\delta_2=\Delta_2 \sin 2(\omega t+\theta_2) \quad [5]$$

$$\delta_3=\Delta_3 \sin 2(\omega t+\theta_3) \quad [6]$$

$\Delta_1, \Delta_2, \Delta_3$=magnitudes of lead or lag of shaft 1 with respect to shaft 0, shaft 2 with respect to shaft 1, and shaft 3 with respect to shaft 2, from equation [1] we may calculate Δ_1, Δ_2, and Δ_3,

where $\Delta_1=Y_0-Y_1$, when $Y_0=45$ deg [7]

$\Delta_2=Y_1-Y_2$, when $Y_1=45$ deg

$\Delta_3=Y_2-Y_3$, when $Y_2=45$ deg

$\delta_1, \delta_2, \delta_3$=instantaneous lead or lag of shaft 1 with respect to shaft 0, shaft 2 with respect to shaft 1, and shaft 3 with respect to shaft 2

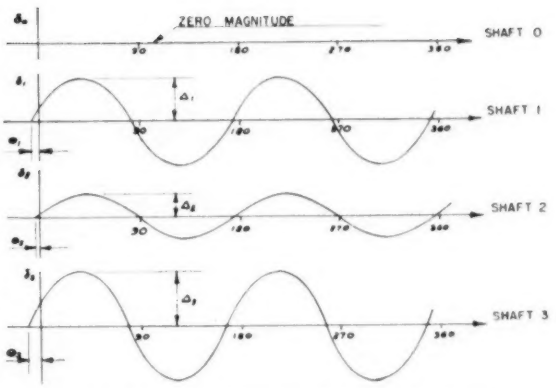


Fig. 5 Lead or lag curves of a three-joint power line

ω=average angular velocity of shafts in radians per second

t=time in seconds

$\theta_1, \theta_2, \theta_3$=phase shift angles of curves 1, 2, and 3 due to angularity between shafts.

Now the whole power line may be considered and the joint yokes located on the shafts at any angle with respect to the first joint.

Let β_2 and β_3 be the joint location angles of joints 2 and 3 with respect to joint 1.

The effect of β_2 and β_3 upon the curves for shafts 2 and 3 is to move them laterally along the horizontal axis as shown in Fig. 6.

The equations for the curves of Fig. 6 now are

$$\delta_1=\Delta_1 \sin 2(\omega t+\theta_1) \quad [8]$$

$$\delta_2=\Delta_2 \sin 2(\omega t+\theta_2+\beta_2) \quad [9]$$

$$\delta_3=\Delta_3 \sin 2(\omega t+\theta_3+\beta_3) \quad [10]$$

Equations [8], [9], and [10] give the actions of each joint, and taken together give the action of the whole power line. As they are sinusoidol functions of the same frequency, and we know the magnitudes and phase relationships, they may be represented by rotating vectors and located on a simple vector diagram. It is this vector diagram which enables us to solve the multijoint power line problem, for, if the vector sum of the three vectors can be made equal to zero, the final driven shaft will rotate at constant angular

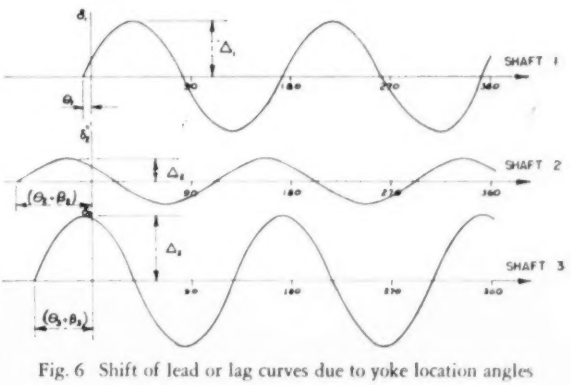


Fig. 6 Shift of lead or lag curves due to yoke location angles

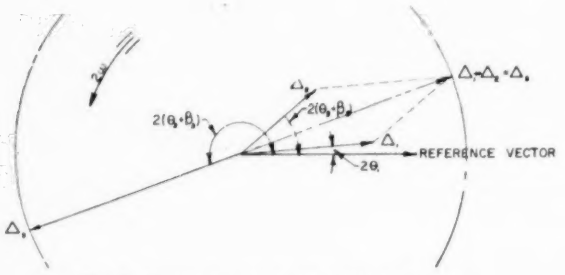


Fig. 7 Vector diagram for three-joint power line

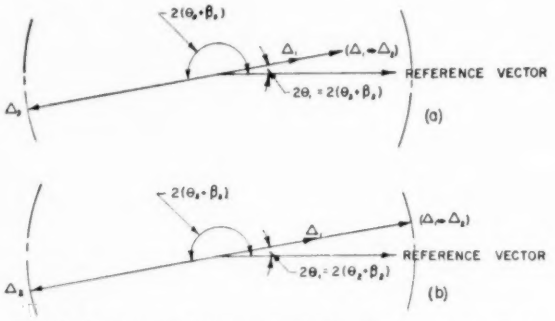


Fig. 8 Analyzing a three-joint power line by the vector method

velocity. A diagram for the general case of the three-joint arrangement is given in Fig. 7.

Vector 1 representing equation [8] may be drawn with magnitude Δ_1 and phase angle $2\theta_1$. The magnitude of vector 2, which represents equation [9], is Δ_2, and its phase angle is 2 $(\theta_2+\beta_2)$ where β_2 may be given any value. Similarly, the magnitude of vector 3 representing equation [10] is Δ_3, and its phase angle is 2 $(\theta_3+\beta_3)$ where β_3 can also have any value. If Δ_3 is greater than Δ_1 or Δ_2 the resultant of vectors 1 and 2 must be made equal in magnitude to Δ_3. This requires a specific value for the phase angle 2 $(\theta_2+\beta_2)$. If the resultant of the three vectors is to be zero, vector 3 must not only be equal in magnitude to the resultant of vectors 1 and 2 but also opposite in phase. Thus the phase angle of vector 3, which is 2 $(\theta_3+\beta_3)$, must be given a suitable value.

From the diagram, the phase angles 2 $(\theta_2+\beta_2)$ and 2 $(\theta_3+\beta_3)$ may be measured or calculated. Since θ_2 and θ_3 are known, then β_2 and β_3 may be determined. The joint location angles which will produce constant angular velocity for the final driven shaft are now known for the given arrangement. The joints may be set easily and accurately in a suitable jig, and for the given shaft angles the power line will operate satisfactorily. (It may be that vectors 2 and 3 will be used to balance vector 1, or vectors 1 and 3 to balance vector 2, but the method of determining β_2 and β_3 remains the same.)

A study of Fig. 7 will indicate that under certain conditions it is quite impossible to reduce the resultant vector to zero. For instance, if the magnitude of one vector should be greater than the algebraic sum of the other two vectors, then even under optimum conditions a finite resultant remains. The only method by which a correct balance may be obtained under such circumstances is (a) to reduce the one shaft angle producing the high magnitude to such a value that the magnitude is less than the algebraic sum of the other two, or (b) to increase one or both of the small magnitude vectors by introducing more angularity into those shafts causing the small magnitudes. It is a relatively simple matter to calculate the minimum increase or decrease in shaft angularity to produce correct balance. In Fig. 8(a) it will be seen that the resultant vector cannot be reduced to zero. Supposing that angle A_3 cannot be altered but changes can be made in angles A_1 and A_2, then the vector diagram is as in Fig. 8(b).

To make Δ_3 equal to the vector sum of Δ_1 and Δ_2, we may change A_1 and A_2 in an infinite variety of ways, but no doubt practical considerations will point to the best change. It may be more satisfactory to have Δ_1 equal to Δ_2, in which case A_1 is equal to A_2 and may be calculated.

From equation [7]

$$\Delta_1 = 45 \text{ deg} - \tan^{-1}[(\tan 45 \text{ deg})\ (\cos A_1)]$$

But we know that $\Delta_1 = \Delta_3/2$

Then $\Delta_3/2 = 45 \text{ deg} - \tan^{-1}[(\tan 45 \text{ deg})\ (\cos A_1)]$

$$A_1 = \cos^{-1}[\tan (45 \text{ deg} - \Delta_3/2)]$$

From equations [2] and [3]

$$\theta_1 = \theta_2 = 45 \text{ deg} - [\tan^{-1}(\cos A_3)]$$

and $\theta_3 = 45 \text{ deg} - [\tan^{-1}(\cos A_3)]$

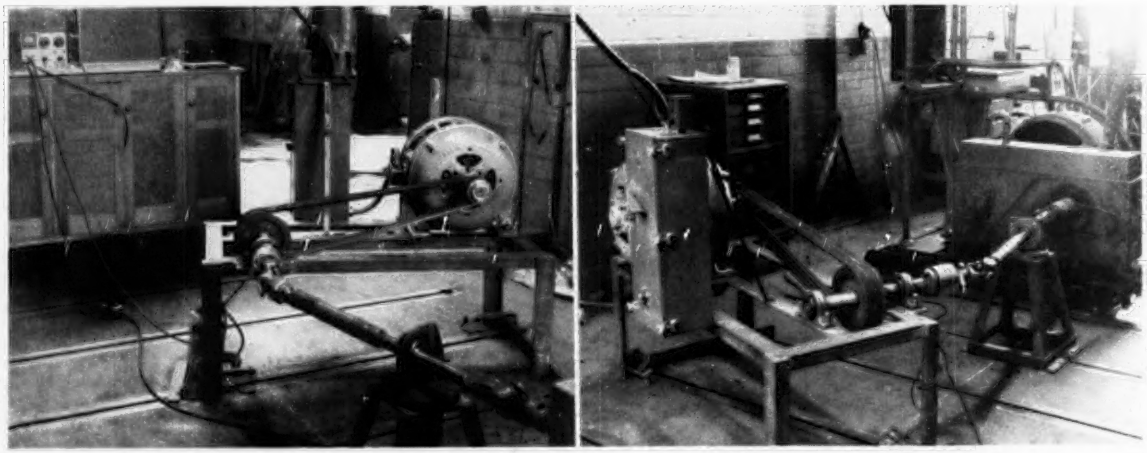


Fig. 9 Two views of a two-joint test setup

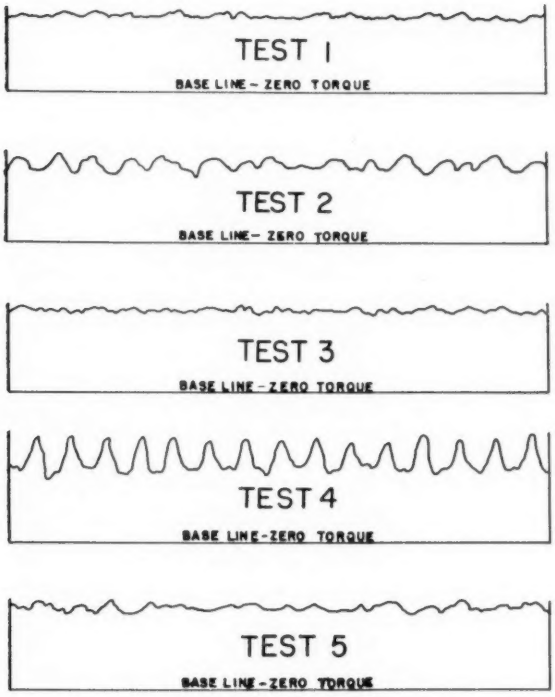


Fig. 10 Oscillograms of tests 1, 2, 3, 4 and 5

From Fig. 8(b)

$2(\theta_3+\beta_3)-2\theta_1=180$ deg

$\therefore \beta_3=90$ deg

Thus we know all the shaft angles and joint location angles required to give constant angular velocity to the final driven shaft. It is obvious that other combinations of change in A_1, A_2 or A_3 may be calculated in a similar fashion to produce the same results.

The above theory was first checked and satisfactorily proven on the test machine of the Mechanics Universal Joint Division of Borg-Warner Corporation, as illustrated in Potgieter's paper of January, 1952. Further tests were made on a power line driven by a 20-hp electric motor and with an electric dynamometer to absorb the power. One of the arrangements is shown in Fig. 9. The torque fluctuations were measured by an electric torque meter and recorded by means of photographing the trace on an oscilloscope. The first phase of the test involved testing a power line with two universal joints; the second, of testing a three-universal-joint power line. To simplify setting up, all work was carried out with the shafts in a horizontal plane. A brief description of the tests conducted follows:

TABLE 1. TEST DATA

TEST	SHAFT ANGLES			YOKE ANGLES		TORQUE (lb-in)		
	A_1	A_2	A_3	B_2	B_3	MAX.	MIN.	RANGE
1	0°	0°	–	90°	–	2480	2105	275
2	20°	20°	–	90°		2600	1980	620
3	0°	0°	0°	90°	0°	2640	2230	410
4	15° 3'	14° 9'	18°	90°	0°	3380	1895	1485
5	15° 3'	14° 9'	18°	40° 30'	108° 30'	2710	2160	550

Test 1. Two universal joints with all shafts in line and with the yokes located 90 deg to each other.

Test 2. Two universal joints with the angles between the shafts being 20 deg and the first and third shafts being parallel. The yokes were located 90 deg to one another.

Test 3. Three universal joints with all shafts in line and with the second and third yokes located at 90 deg and 0 deg with respect to the first yoke.

Test 4. Three universal joints with the shafts set at arbitrary angles to each other and with the second and third yokes located at 90 deg and 0 deg with respect to the first yoke.

Test 5. Three universal joints with the shafts as set for Test 4 but with the second and third yokes rotated to produce a constant speed at the final driven shaft.

Examining Table 1 will indicate the variations in torque with the different power-line arrangements. The information in Table 1 was obtained from the oscillograms shown in Fig. 10. Theoretically, the records obtained in tests 1, 2, 3 and 5 should have been similar; however, it is believed that setup errors, machine errors, normal loose fits in the telescoping sections, and vibration induced by the above are largely responsible for the torque fluctuation obtained. Even considering the above errors, the results of test 5 compared very favorably to those of test 2 which is the accepted optimum. The above information shows that, wherever the shaft angles in a power line do not alter, it is often possible to reduce the torque fluctuation to a safe level.

It is not suggested that the above analysis will answer all or any of the farm machinery power-line problems, but it does enable the designers to determine the effects of angularity between shafts on both power unit and driven machinery. Care must be taken to check the effects of altering the shaft angles due to relative changes in position of tractor and implement when analyzing power lines.

Recording Torquemeter

(Continued from page 307)

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A Harvester for Ireland's Sugar Beets

Austin A. Armer
MEMBER ASAE

WHEN an agricultural engineer accepts an appointment as a consultant with the Technical Assistance Program of the Mutual Security Administration, his most vivid imagination cannot picture the nature of the problem or its solution until he has arrived on the foreign shore and learned something of the customs of the new country, and faced up squarely to a set of agricultural and economic circumstances altogether at variance with those in his own country.

The author's contract with MSA stated that "the consultant will be expected to advise and assist on the improvement and modification which might be made in beet harvesting machinery to meet Irish conditions."

A month's study of "Irish conditions" revealed that by western United States standards any sort of beet-harvesting machinery was definitely contraindicated. Nearly all the conditions of Irish sugar beet fields at harvest time are the very conditions which make mechanical harvesting impossible or impractical in the United States. The fields are soaked to near capacity by constant rainfall; the beets are planted for the most part by single-row planters, such that row spacing is never constant; and the beet fields abound in stones of all sizes and are on slopes so steep that an unloaded tractor has difficulty climbing them.

In the face of this array of antagonistic conditions, there are now in the sugar-beet fields of Ireland 150 harvesting machines fabricated from a design which grew out of a 30-day examination of the conditions, together with a prototype machine built within another thirty days.

DESCRIPTION OF THE PROTOTYPE HARVESTER

The concept of the machine (and the prototype embodying this concept) was based principally upon a series of restrictions; that is to say, field conditions dictated that nearly all the principles employed in successful beet harvesters the world over had to be rejected for reasons of climate, soil conditions, and cultural methods. These restrictions left little choice of design constants, and the basic features adopted were as follows:

1 A tractor-mounted unit, installed on a four-wheel tractor of the make principally available in southern Ireland.

2 Loosening of the beets by a single shovel-type plow.

3 Grasping of the beet foliage by a pair of V-belts back-to-back.

(Continued on page 314)

This paper was presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at San Luis Obispo, Calif., February, 1953.

The author — AUSTIN A. ARMER — is agricultural engineer Spreckels Sugar Co., Sacramento, Calif.

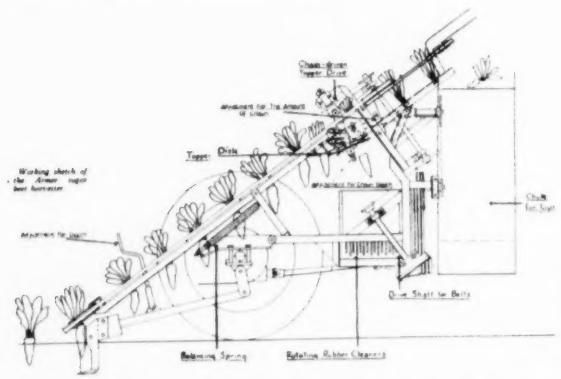

Topper Disk
Chain for Topper Drive
Adjustment for The Amount of Crown
Working sketch of the Armer beet harvester
Adjustment for Crown Depth
Drive Shaft to Belts
Retaining Spring
Rotation Rubber Cleaners

Fig. 1. Schematic diagram of basic elements of the Armer beet harvester

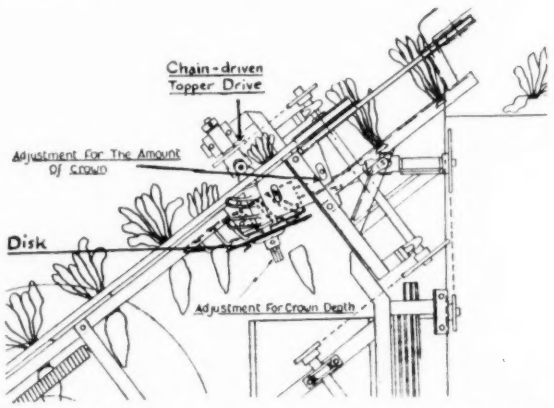


Fig. 2 Schematic detail of the topping system of the Armer harvester

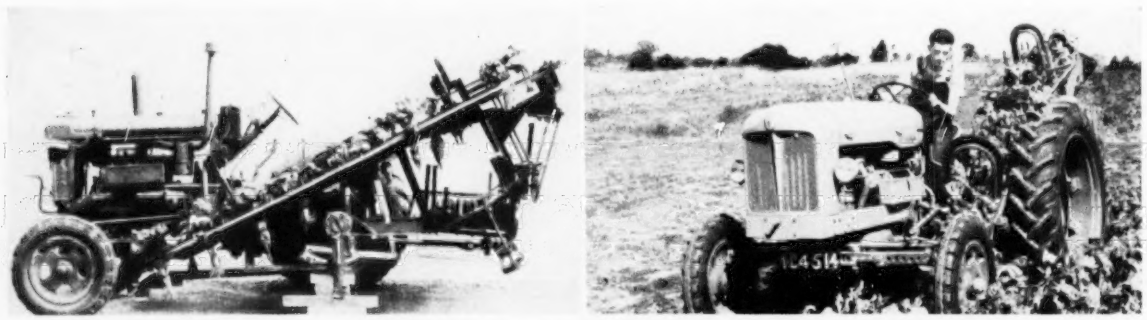


Fig. 3 (*Left*) Shop view of the Armer beet harvester with tractor rear wheel removed • (*Right*) The Armer harvester in operation near Carlow, Ireland

Comfort Zone Patterns in Infrared Brooding

John E. Nicholas
FELLOW ASAE

FLEXIBILITY and ease of application of heat from infrared lamps renders them useful tools, in single or multiple units, for brooding chicks, pigs, lambs or other newborn farm animals. Output of heat or energy from a 250-w, 110-v infrared lamp is greater at 1.2 μ (microns) or 12,000 A (Angstrom units), but its heat production covers a band on the spectrum ranging from 0.8 to 2.0 μ or 8,000 to 20,000 A. The effects of this particular range of spectral wave length on biological specimens deserves further study.

The heat output distribution of electric heating elements and the resulting pattern of the comfort zone is analyzed easily by permitting the radiation to be absorbed and by measuring the heating effect produced. Trials of this kind are reported in an article, entitled "Thermal Characteristics of Electric Brooder" in AGRICULTURAL ENGINEERING for August, 1939 (vol. 20). In preliminary chick-brooding trials, rays from an infrared lamp were allowed to fall on and be absorbed by litter, the resulting radiation being measured by the use of thermocouples.

What the results of this radiation on live chicks would be under identical conditions can be determined best by study of the chicks' behavior. This undoubtedly would vary with time of year, temperature, humidity, and age of chicks.

METHODS OF STUDY OF COMFORT ZONE

The laboratory study of the heat output and comfort-zone pattern was made by suspending a red-jacketed 250-w infrared lamp over the center of a 3 x 3½-ft wood box 3 in deep filled with sawdust.

This paper was prepared expressly for AGRICULTURAL ENGINEERING. Authorized for publication on March 17, 1953, as paper No. 1794 in the Journal series of the Pennsylvania Agricultural Experiment Station.

The author — JOHN E. NICHOLAS — is professor of agricultural engineering, Pennsylvania State College.

Author's Note: The author gratefully acknowledges the assistance of John S. Perry in the preparation of the drawings accompanying this article.

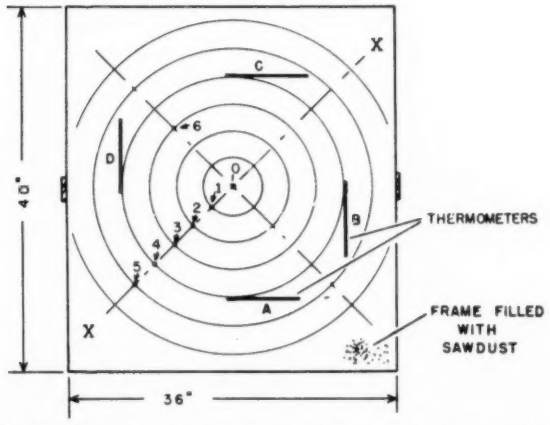


Fig. 1 Plan view of the experimental setup with thermocouples 0, 1, 2, 3, 4 and 5 at center and 3-in intervals radially

The thermocouple arrangement and the location of the 4 thermometers placed on top of sawdust to determine comfort zone temperatures are shown in Fig. 1, a plan view of the experimental setup. Fig. 2 illustrates the relative positions dimensionally. Floor temperatures were obtained by thermometers located 6 in from the wood box.

Connecting the lamp to the available power line showed utilization of volts=116, amperes=2.15, and watts=245.

The study was carried out in the laboratory, and temperature readings were recorded almost as soon as the lamp was connected, then repeated at half-hour intervals until no further rises in temperatures were noted. After 1¾ hr of continuous operation of the lamps at a height of 18 in above the litter, the resulting readings of the thermocouples were plotted in Fig. 3. Thermometers on top of the sawdust have no special significance. Each recorded only the resulting effect of the heat absorbed at this point.

The lamp was then lowered 2 in and data again recorded with it 16 in above the litter. Lowering of the lamp to 14 in above the litter provided a comfort zone after 10 min that was relatively unchanged after 2 hr and 20 min of continuous heating.

There was no appreciable change in the pattern of the comfort zone area by prolonged heating. A check test with the lamp hanging 18 in above the litter connected all night — 5:00 p.m. to 8:30 a.m. next morning — showed the pattern to be identical with Fig. 3 with the lamp at the 18-in height previously obtained.

DISCUSSION

With the lamp at the 18-in height, the zone areas beyond the 9-in radius were not quite as warm as with the lamp at the 14-in height.

Because of the lamp's parabolic internal reflector, it might be conceived that lowering the lamp from 18 to 14 in would "decrease" the comfort zone area at the outer fringes of the relatively hot central cone. Fig. 3 shows that this fringe area is warmer with the lamp 14-in above the litter than 18 in.

"Thermal Characteristics of Electric Brooders" — The article previously referred to — reports that a circular canopy brooder with a centrally located coiled wire heat-

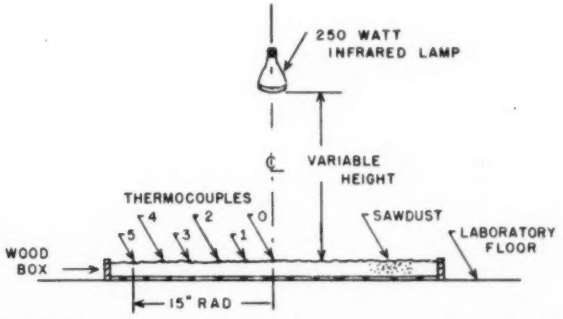


Fig. 2 Cross section on line X-X (Fig. 1) indicating relative portion of lamp and the variable height above wood box

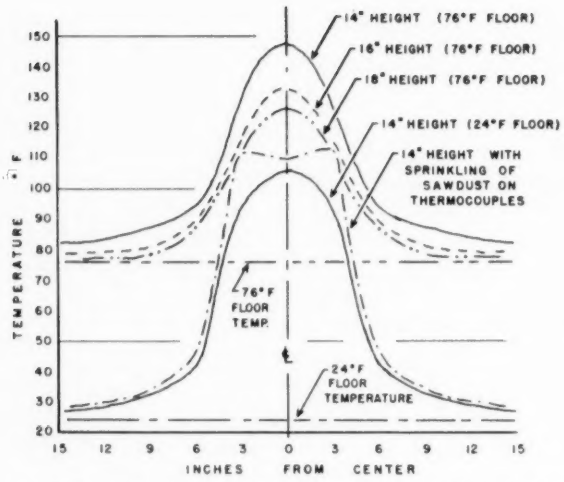


Fig. 3 Comfort zone patterns with 250-w infrared lamp at 14-in, 16-in and 18-in heights, with 76 and 24 F floor temperature

ing element produced a similar comfort zone (Fig. 3) having a temperature of 166 F at its center. Apparently at that time no fear of the possibility of fire hazard with the hover type of brooder was expressed. The infrared lamp, properly suspended 14 in above the litter produced a temperature of 150F at the center of comfort zone pattern and a larger useful heat pattern on the fringes than at the 18-in height.

Temperatures recorded by thermocouples result from the heat effect produced at the location of the thermocouple junction. The thermocouples, in general, were located a small fraction of an inch in air, above the sawdust.

That a possible change in the heat pattern can be produced easily is shown in Fig. 3. A thin sprinkling of sawdust over the couples brought about immediate temperature response. In this case the lamp was at the 14-in height and the air at the floor had a temperature of 24 F. The graph shows temperatures under the lamp before and after sprinkling. As soon as material is made available which will absorb radiation, the resulting heating effect is immediately changed.

Since chick comfort should be based on a live-chick behavior, and their response, the data here reported has relative value for guidance in the use of the infrared lamp in brooding.

Harvester for Sugar Beets

(Continued from page 312)

4 Elevating the beets by the inclined V-belts to a topping mechanism.

5 A topping device comprising a pair of bullet-shaped, counter-rotating members with helical flights, which at once grasps the stems of the beets, positions the beet roots, and propels the beets horizontally past a pair of sharpened disks which sever the roots from the crowns.

6 A beet-cleaning screen to shake off adhering soil.

7 A small storage bin for beet roots with a trap door release.

8 A chute for tops with a trap door release.

9 Controls for dropping alternate heaps of roots and tops.

The prototype embodying these features demonstrated that the machine was capable of meeting most field conditions. There were a number of design changes made necessary after the prototype was tried in the field, and in the absence of the design engineer, the agricultural development officer of the Irish Sugar Company, Ltd., with his staff of mechanics and the mechanical engineer revised the prototype design and supervised the construction of 150 machines.

LIMITATIONS OF MANUFACTURING FACILITIES

The Republic of Ireland is essentially an agricultural country dominated by pasture and livestock production. Mechanized agriculture, as known in western United States, is almost unknown. There are no mass-production farm implement factories, and none of the lavishly equipped rural machine shops, which characterize the western agricultural areas in this country. Thus a design had to be suited to the manufacturing facilities which included

1 Grey iron, aluminum and brass foundries.

2 Jobbing machine shops, provided with engine lathes, drill presses, arc and acetylene welding and cutting equipment.

3 Limited stocks of steel, principally a few bar sizes of angles, flats, and rounds.

4 An almost complete absence of stocks of machine elements such as sprockets, chain, V-belts, sheaves, antifriction bearings, etc.

Facilities for building the prototype consisted largely of the maintenance shops and storeroom of the Irish Sugar Company's factory at Carlow. Special credit must be given to the maintenance staff of the factory, since their isolation from the large European machinery centers had developed an astonishing sense of resourcefulness.

Adding to the difficulty of designing a machine for economical production was the fact that available materials (principally steel shafting, tubing and structural shapes) might be found either in metric or English dimensions. The machinists and mechanics of the maintenance staff were equally at home in the English and metric systems, and carried at all times a mental conversion table of amazing accuracy.

THE SIGNIFICANCE OF A TECHNICAL ASSISTANCE PROGRAM

An agricultural engineer whose background has been design and application of farm machinery discovers a new dimension when he accepts the responsibility of a consultant with the Technical Assistance Program. In addition to the elements of agricultural engineering (commonly defined as the application of the science of mechanics to the solution of agricultural problems), this new dimension deals with the relationship between peoples of widely differing backgrounds and customs. In the experience related here, which is perhaps typical of many successful Technical Assistance projects, success was not so much in the nature of applying stereotyped engineering principles, as it was the relation between an individual or group with specialized engineering training and a beneficiary group whose contribution was a remarkable complex of enthusiasm, willingness to co-operate, and boundless determination to put to full use all of the consultant's capabilities.

Engineers Advance Art of Making Grass Silage

Paul A. Whisler and George V. Frushour
MEMBER ASAE MEMBER ASAE

GREAT as are the advantages of grass silage in a livestock feeding program, the spread of this system of harvesting grass and legume crops, and its acceptance by farmers, although farily rapid in the past ten years, undoubtedly has been retarded by an air of mystery, misunderstanding, and confusion about how grass silage should be made and handled.

The engineers in the harvesting division of the Allis-Chalmers organization have been engaged for about 15 years in developing a line of forage-harvesting equipment, and in connection with the experimental work with these machines they have filled nearly 200 silos with grass and legume silage under a wide range of operating conditions. Observations based on this work, supplemented by the experiences of farmers who have bought and used production machines, indicate that the making of good grass silage is not so sensitive, difficult or complicated as has been generally believed.

It is not the primary purpose of this paper to tell anyone how to make silage. The paper is intended to present only for study the results observed during the test work, as well as the conclusions drawn from these results. It is hoped that the report may help remove some of the mystery and fear of failure from the making of good grass silage and advance the time when farmers will approach silage harvest with the same understanding and confidence that they do their grain or corn harvest.

While development on forage-harvesting machines began in the summer of 1938, this report is based primarily on the period between 1942 and 1952 inclusive, in which a fairly well-defined test program was followed. In this 11-year period, at least 11,000 tons of grass silage were harvested with experimental equipment operated by personnel of the Allis-Chalmers engineering department at the La Porte, Ind., works. The work was more or less evenly divided at approximately 1000 tons per year. During 1942 and 1943, most of the harvesting was done in cooperation with the agricultural engineering department of the University of Wisconsin and with the U.S. and the Ohio Agricultural Experiment Station at Wooster, Ohio. In 1944 the project at Wooster was continued, and in addition ten silos were filled in La Porte County, Indiana. Since then all work has been done in the vicinity of La Porte.

The silage made at La Porte was put up on average farms under the usual varying conditions. Allis-Chalmers supplied the machinery and tractor operators, but the method of harvest conformed as nearly as possible to the way in which the farmer wanted it done.

Crops Harvested. During the 11-year period, almost every kind and combination of forage crop grown in this part of the country has been harvested with the exception of soybeans alone. Small amounts of soybeans with Sudan grass and soybeans with corn have been harvested, but no one apparently wanted to ensile straight soybeans. The predominant crops cut were alfalfa, clovers of all varieties, alfalfa-grass mixtures, clover-grass mixtures, and alfalfa-clover-grass mixtures. A few straight grain crops of oats, wheat, and rye were cut, as well as a few all-grass crops of Sudan, timothy, canary, blue grass, and alta-fescue. Most of the grasses in the legume-grass mixtures were timothy, brome, and orchard grass. Some crops contained many weeds.

Most of our work was done with first-cutting crops harvested in May, June, and July, but a few second and one third cutting were ensiled later in the season.

The moisture content of these crops varied from 89 percent in prebloom Ladino and red clover to 50 percent in wheat. During 1949 and since the moisture content has been recorded as the material went into the silo by the "French-fry" method, in which weighed samples are dehydrated in hot cooking oil and then weighed again. A Toledo moisture tester was used prior to 1949.

Method of Harvest. Almost all of the silage was cut direct from the standing crop. A small amount of wilted silage was put up from the windrow for the experiment station at Wooster, and in 1948 one silo at La Porte was filled with wilted alfalfa-brome which had been cut for dry hay at the start of a rainy spell. Although equipment for both direct-cut and windrow pickup was available, all the farmers preferred direct cut. A few times they were asked to permit windrowing for experimental purposes. In 1949 three silos were filled with material picked up, without wilting, directly back of an experimental windrower to get "mileage" on the windrower. During 1951, to try out a special pickup, one small silo was filled with windrowed material which was too old and dry to be cut at all. The only other windrowed silage made was an occasional part of a silo to try other experimental features.

In this picture a grass mixture is being cut and chopped for silage — with an Allis-Chalmers tractor and forage harvester

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at New Orleans, La., February, 1953.

The authors — PAUL A. WHISLER and GEORGE V. FRUSHOUR — are engineers in the harvester division of Allis-Chalmers Mfg. Co.

The theoretical length of cut used varied from ⅜ in to as much as 1½ in. In general, longer cuts were used on higher moisture content materials and shorter cuts on drier materials. In recent years much of the work has been done at about ¾ in cut.

Method of Storing. Most of the silage was blown into conventional upright silos with experimental blowers. The silos varied from 6 x 15 ft to 16 x 50 ft and were of all different constructions and conditions. Most of them were of concrete-stave construction, without covers, in fair condition and approximately 12 x 35 ft to 12 x 45 ft in size. Several hundred tons were placed in trench silos.

Prior to 1944, additives in the form of molasses or ground grain were used in all but two or three silos a year. The amount of additives used per ton was approximately in accord with published recommendations of colleges and experiment stations. Since 1944, however, as the good results of the few "no preservative" pioneers became known around the country, about 75 percent of the material ensiled has had nothing added. Also, since then, when additives were used, the amount per ton has generally been decreased from the recommended amounts. In 1950 and 1951, the few farmers who added molasses did so not as a preservative, but in order to have extra carbohydrates in the winter ration. Ground grains have not been used since 1949. No additives at all were used in 1952.

In earlier years, many farmers attempted to tramp and distribute the silage evenly as it was put in the silo. For the last few years, however, no one has done any tramping or leveling except for a few feet at the top of the silo.

Evaluation of Resultant Silage. Since the major purpose of the experimental silage program was the improvement of machine performance rather than the study of effects of methods used on silage quality, no technical procedure was attempted to determine how "good" or how "bad" the material was when fed or what the results were in livestock or milk production. Most of the silage, however, was examined by someone from Allis-Chalmers during the feeding season or after the silage had had a chance to cure. Also, wherever possible, results were discussed with the farmer after the silage had been fed and his opinion obtained about the quality and feeding characteristics.

Judgment of quality was based on smell, taste, color, general appearance, and feel of the silage as compared to previous samples which experience had shown to be feed readily acceptable to livestock.

The past four season's results of our experimental silage program have been summarized and made available in condensed form, and mention of individual farmer experiences that follows have reference to this tabulated data.*

RESULTS OBSERVED

By far the most outstanding result observed from this project is that, all crops which met all of the following conditions when harvested, produced silage which was rated excellent or very good:

1 Crop moisture content was above 70 per cent.

2 Stage of maturity was not beyond the point where parts of the plant were beginning to die.

3 Crop was harvested by direct cut.

4 Crop was ensiled without additives.

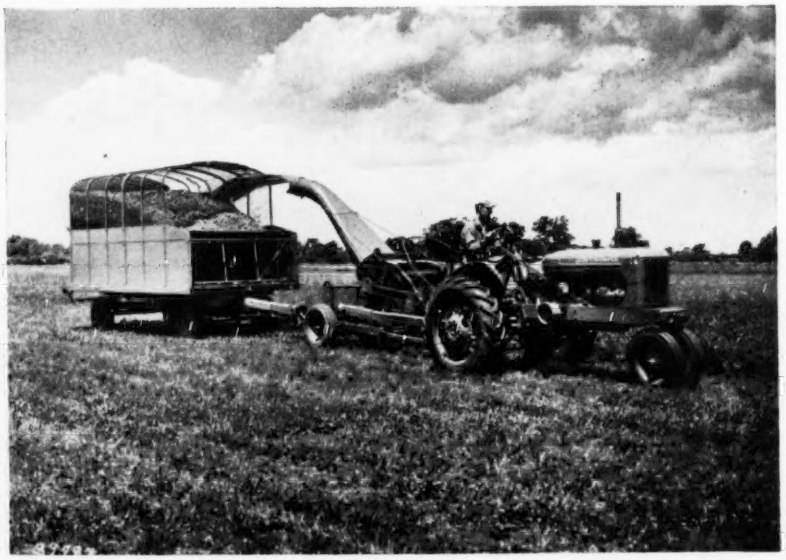
5 Crop was ensiled immediately after cutting, in a silo which permitted ample free drainage for excess moisture.

Moisture. High moisture content of the crop appeared to be one of the most important factors in making silage of high quality. In some cases crops between 60 and 70 percent moisture made good silage, but in general it was inferior in color, odor, and taste, showed evidence of excessive heating, and had more top and side spoilage than the greener crops.

Maturity. The stage of growth seemed to have less effect on quality than moisture content, as long as the crop was not past full maturity. Crops that were past their peak of growth and had dry or dead blossoms or leaves occasionally did not make top quality silage even where moisture content was around 70 percent. In general, the more immature crops made the best silage. The selection of the five "best" samples made in this 11-year period are all from crops of high moisture content and in the early stage of growth. The number one selection is the silage made in 1952 on the Arden Baske farm, of 89 percent moisture, very immature prebloom Ladino and red clover.

Method of Harvesting. Windrowed crops picked up directly behind the rake or windrower without wilting made good silage in several cases. In others, frequent spoiled or rotten spots occurred, apparently because trash, dirt, or manure had been picked up. In one of these cases,

*On request the authors will supply tabulated data summarizing ensiling conditions and results on individual farms in the La Porte, Ind., area for the years 1949 to 1952 inclusive. Address Advertising Dept., Tractor Division, Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.



Field cutting and chopping clover for silage with the Allis-Chalmers tractor and forage harvester shown here greatly simplifies the field operations incident to making silage

on the C. E. Lindborg farm in 1949, 15 tons of direct-cut rye silage placed in the bottom of the silo was in excellent condition when fed, 37 tons of windrowed alfalfa silage placed in the center showed numerous spoiled pockets, and 10 tons of direct-cut alfalfa silage placed on top and cut from the same field as the windrowed silage during the same day was of excellent quality. The field had a very heavy application of manure, some of which was picked up in the windrow but not picked up with the sickle during the direct-cutting operation.

The small amount of wilted silage harvested in this test work was insufficient as a basis for reliable conclusions as to the resulting silage quality. None of the material put up, however, and none of the several samples of wilted silage examined from other sources was what the authors would consider top-quality silage. Doubtless good wilted silage has been made, but all that was seen lacked the green color, the pleasing, tangy aroma and the fresh taste of good direct-cut silage. It has seemed more susceptible to overheating, moldy spots, and top and side spoilage. It was observed that under farm conditions it was impossible to control the wilting time accurately enough to prevent putting in at least some material that was well under the 70 percent moisture content which these tests indicate is necessary for good silage. It was also observed that wilted crops did not pack as well in the silo and therefore required more silo capacity for a given amount of feed.

Additives. When molasses, either liquid or dry, was used as an additive and the rest of the above five conditions met, results were equally good. No appreciable improvement, however, was observed over the same or similar crops ensiled without additives.

When dry preservatives such as ground grains were used, the resulting quality of silage was not consistently good. Even with moisture contents above 70 percent and the amount of grain additive below the recommended amounts, spots of moldy, overheated, spoiled silage were common where slightly higher than the average of grain concentration occurred.

Storage Conditions. There is an indication that crops should be ensiled quickly after chopping, and that once started a silo should be finished without too much delay. On several occasions where silage was allowed to remain on the wagon overnight and placed in the silo the next day, a layer of poor quality silage resulted. When operations were suspended for several days and filling started again in the same silo without removing the top layer, localized poor quality also resulted.

It appears that silos should have some provision for permitting free drainage of excess moisture to obtain top-quality silage. In a few cases where silos were tight, with no floor drain and close-fitting doors, the silage, in the lower part of the silo especially, was waterlogged and "off" in odor and appearance, although most of it was still acceptable to livestock. All silos that contained good silage had at least some drainage. There is also an indication that the speed with which a silo can drain has some effect on quality. All silos that were in poor condition, that is, with cracks and loose joints which permitted leakage through the walls (farms of Ray Herrold, D. P. Hannon, Vincent Thies, and H. Hagenow), consistently produced superior quality silage with just a little better color, taste, and aroma than similar crops put in tight silos which did not have ample drainage.

This does not mean that silos with tight walls will not make good silage. Experience indicates that free drainage should be provided from the bottom of the silo. The number one sample, mentioned previously, made on the Baske farm in 1952, was placed in a tight silo in which an open drain had been installed in the floor.

Silos do not have to be as tight for grass as for corn silage, as was shown by the fire-damaged silo on the farm of Ray Herrold. This silo has been filled with grass in the spring and corn in the fall for several years. With corn, a large amount of side spoilage and mold has occurred around cracks and loose joints. With grass, no side spoilage or mold has occurred when the crops were above 70 percent moisture.

No difference has been apparent in quality when silage has been tramped all the way up or merely topped out for the upper six or eight feet.

Results have been as good in trench silos as in upright silos. Ample drainage should be provided to prevent the bottom of the trench from trapping liquids. Experience has indicated that silos in which heavy green material is used as topping have less spoilage than those using dry porous material like straw. Also toppings that were well crowned and extended out over the edge of the trench seemed to prevent side spoilage from runoff water that occurred when trenches were topped out flat or not quite full. Because of the lack of depth it is more imperative to have high-moisture crops in trenches than in upright silos.

In 1952, on the A. H. Warneke farm, a trench silo and stack were combined with good results. Because of lack of capacity, after the trench was filled, the chopped material, 80.5 percent moisture alfalfa and clover, was built up to a height of 15 ft above the ground level, on top of the material already in the trench. A blower was used to place the crop on the stack. The silage was compacted by a tractor and finished off by well rounding the top and raking the loose material from the sides. No cover was used. Spoilage was only about 3 in on top and sides and quality was good both in the stack and trench portions. A tile drain had been provided in the bottom of the trench, but in this case was not necessary because the excess moisture was carried off through the sandy loam trench sides and bottom.

There is no indication as to which crop makes the "best" silage. All green crops have made excellent silage when properly handled. Silage from straight clover or a mixture high in clover usually has a slightly sweeter smell and taste than comparable silages of alfalfa or alfalfa mixtures. The clover, however, should be cut before any leaves or blossoms become dead for this to be true. Naturally crops low in food value such as rye will not make as good feed as high-protein legumes. Legume silages high in moisture, that is over 75 percent, seemed to give slightly better silage if cut ¾ in or more, theoretical cut, whereas lower moisture crops and all straight grain crops seemed better if cut ½ in or less.

Quality (Farmers' Opinions). In practically all cases, the farmers' report, after feeding the silage, agreed with the authors' opinion of the quality. The most conclusive proof of their satisfaction is that as far as is known all farmers for whom grass silage was harvested prior to 1952, and

who are still feeding livestock, have continued to use it for at least part of their feeding program, with one exception (Joe Tuholski, 1949). Many of them are now using grass exclusively for their silage requirements.

Many farmers have tried silage both with and without additives of different forms. All have stopped using ground grains and most of them prefer silage plain with no additive.

Feeding Results. No careful check has been made on the milk or meat production resulting from feeding grass silage. Many farmers have reported, however, that both quality and quantity of milk has gone up when changing from corn silage or pasture to grass silage. There have been no reports of decreased production except in the case of low food-value crops such as rye. Several beef cattle feeders claim that they get better gains from grass than from corn silage.

When proper feeding practices have been followed, the "cow acceptance" of good quality silage has been 100 percent. Cows have been known to leave good knee-deep alfalfa pasture to get a sample of high-moisture, no-preservative, direct-cut, alfalfa silage. A few farmers have had trouble with feeding until they learned that there is more concentrated food in a scoop full of grass silage than there is in a like amount of corn silage.

Production Machine Results. Aside from this work with experimental forage harvesters, some of the results obtained with thousands of production machines now in the field have been observed or reported. In these cases, results agree with the above findings. For example, a second-cutting crop of green succulent early-bloom alfalfa-brome silage was cut direct and ensiled with no additive on the farm of the late H. E. Babcock near Ithaca, N.Y., in the summer of 1948. A sample of this material won the New York state grass silage championship that season.

In 1951, on a branch farm of the Wisconsin Agricultural Experiment Station at Marshfield, a large rectangular stack of high-moisture, medium-maturity legume crop was put up without wilting and without preservative. The branch experiment station superintendent, Russell Johannes, reported the silage was of excellent quality, with only a very small amount of top and side spoilage.

Grass silage stacking operations observed on several other farms showed equally good results where crops were not too dry or mature. Among these were three stacks on the farm of C. B. Watson, President of the Corn Belt Livestock Feeders Association, DeKalb, Ill., in 1951. Mr. Watson continued stacking all his grass silage in 1952, even though he has upright silos available.

Factors Contributing to the Results. The authors realize that the procedures and results reported in this paper disagree with the recommendations and findings of some silage authorities, and the following five points are offered in possible explanation of this difference:

1 Most tests by colleges and agricultural experiment stations were conducted without the benefit of new forage-handling equipment capable of harvesting crop by direct cut.

2 Silage cut direct is apt to be cleaner when it goes into the silo than that which is first windrowed. There may be a corresponding decrease in the amount of bacteria which cause spoilage.

3 A much shorter time elapses between the cutting and ensiling of a crop cut direct, which may affect the chemistry of the silage process.

4 In this work, facilities for free drainage have been generally present, whereas in most experimental work tight sealing has been practiced.

5 At least some of the other experimental work has been done under conditions that vary greatly from those actually encountered on the farm.

CONCLUSIONS

From the experiences and observations, in connection with this experimental program the following tentative conclusions are suggested:

1 The simplest, most economical, most foolproof way to make good grass and legume silage under farm conditions appears to be to cut the crop direct and ensile without additive.

2 Many farmers prefer this method because:

(a) A saving in time, labor, and cost results by eliminating mowing and raking.

(b) The direct-cut method reduces weather hazards and the danger of loss of the crop.

(c) The crop can be harvested without picking up dirt, trash, and manure, and results in cleaner feed.

(d) There is less danger of machine damage and lost time from picking up stones, pieces of iron, and other foreign objects.

(e) Power requirements are less and the uniformity of cut is better.

(f) The time of harvest can be better controlled to fit other jobs and chores on the farm.

(g) The entire operation is much simpler. It requires less judgment of crop-moisture conditions and less coordination and timing of the various operations than are required by the wilting system.

3 Good quality silage will generally result when using the direct-cut, no-additive method if all the following four conditions are met:

(a) If moisture content of crop is above 70 percent

(b) If stage of maturity of crop is not beyond the point where parts of the plant are beginning to die

(c) If crop is ensiled immediately after cutting with as little delay as possible in the entire filling operation

(d) If crop is ensiled in a silo which permits ample rapid drainage of excess moisture.

4 The one most important practice in obtaining good silage is to harvest at a high moisture content. It was observed that much more silage is spoiled on the farm by being too dry than by being too wet.

5 Grass silage can be successfully stored in trenches or stacks if, in addition to the conditions in paragraph 3 above, the material is well compacted and rounded out on top and protected from surface-water drainage. Moisture contents as high as possible will give the least top and side spoilage in this type of storage.

The authors are aware that their work has not been extensive enough to guarantee similar results under every crop, climate, and silo condition that exists throughout this country. They contend, however, that the direct-cut, additive-free system is so far, the simplest, most economical grass-silage-harvesting process known, and that it has produced consistently good results under the conditions set forth in this paper.

Results of Evapotranspiration and Root Distribution Studies

William B. Land and John R. Carreker
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RESEARCH results from studies of the rate of evapotranspiration and root distribution under irrigated crops in 1952 are reported in this paper. These studies were part of a project on supplemental irrigation being conducted cooperatively by the Soil Conservation Service (Research) (recently transferred to the Bureau of Plant Industry, Soils and Agricultural Engineering), U. S. Department of Agriculture, and the agricultural engineering department, college experiment station, University of Georgia Agricultural Experiment Stations.

The rate of evapotranspiration by crops is one of the major factors affecting the design of irrigation systems, yet little research data are available in the eastern United States on evapotranspiration rates. Several processes are available by which these values are estimated. Chief of these are the Blaney-Criddle method of computing consumptive use and the Thornthwaite method of estimating evapotranspiration.

The Blaney-Criddle* method gives consideration to temperature and daytime hours as the most important factors influencing consumptive use. The consumptive-use requirement is obtained by multiplying the mean monthly temperature with the monthly per cent of daytime hours. The value so obtained, less the precipitation, gives the irrigation requirement. The irrigation program of the Soil Conservation Service in the southeastern region is based on estimated values of consumptive use of water obtained with this method.

The Thornthwaite theory of evapotranspiration employs an empirical formula based on latitude and average temperature of the air as the only variables. Knowing these factors, the average daily values are computed for periods throughout the growing season. Von Bavel and Wilson† showed how the values so computed can be utilized in a "bank account" of available soil moisture. Rainfall and irrigation add to the moisture balance and the daily evapotranspiration reduces the quantity present. When enough days have elapsed to reduce the balance to near zero, irrigation is needed.

These methods of estimating moisture withdrawal from the soil are important tools in helping conduct present irrigation programs. However, daily and periodic rates of evapotranspiration need to be measured under humid conditions for a better evaluation of their reliability for determining when irrigation is needed.

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at New Orleans, La., February, 1953.

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*Blaney, Harry F. and Criddle, Wayne D. Determining water requirements in irrigated areas from climatological and irrigation data. SCS-TP-96, August, 1950.

†Von Bavel, C. H. M. and Wilson, T. V. Evapotranspiration estimates as criteria for determining time of irrigation. AGRICULTURAL ENGINEERING, vol. 33, pp. 417–418, 420, July, 1952.

PLAN OF EXPERIMENT

The irrigation studies described in this paper were conducted in 1952 on an upland field at the Southern Piedmont Conservation Experiment Station. The site was within one terrace interval area with a land slope of about 5 per cent. The soil was a Cecil sandy loam, which is derived from very old and deeply weathered igneous and metamorphic rock.

The crops grown were tomatoes, pole beans, corn and cotton. We chose these to represent vegetable and field crops of high economic value and common to the agriculture of this area. The rooting habits of these crops varied from fibrous to tap-root systems.

Kobe lespedeza stubble was turned into the soil early in April and a broadcast application of 600 lb per acre of 0-14-10 fertilizer was made over all plots ahead of planting. Each crop was fertilized with 500 lb per acre of 6-8-6 fertilizer in the row at planting. Corn was replanted due to crow damage and an additional 250 lb per acre of 6-8-6 fertilizer was applied in the row. All crops were later side-dressed with 33 per cent ammonium nitrate, the corn and cotton receiving 100 lb per acre and the beans and tomatoes 150 lb per acre. All cultural practices were uniform for a given crop on each plot. The varieties of the crops used were Stokecross hybrid tomatoes, Alabama No. 1 pole beans, NC 27 hybrid corn and Empire cotton.

The treatment variables included irrigation versus none, with 4 replicates of each treatment. Irrigation applications were made as nearly as possible when 25 to 35 per cent of the available moisture was left in the soil. The computed rate of application was 0.40 in per hr. Standard rain gages were used to measure the quantity of water actually applied to each plot.

Runoff was measured from representative plots so that a record of the net water entering the soil from rains and irrigation was obtained. The runoff plots were 24.9 in wide and 42 in long, making 1/6000 acre. The length extended across one row width. Wooden borders on three sides separated the plot from the adjacent area. A sheet metal trough at the lower edge concentrated the water into a pipe that lead downhill to a measuring can.

Soil moisture records were obtained from samples taken in each plot at 0-6, 6-12 and 12-18 in depths. Samples were taken before each irrigation, one day following each irrigation and rain, and at 2 or 3-day intervals between these readings. The per cent moisture was determined by weighing and oven-drying.

The per cent moisture data were converted to inches of available moisture in the soil by the formula

$$AW = \text{soil depth in inches} \times \text{volume weight} \times (M - WP)/100$$

where AW = inches of available moisture

M = per cent soil moisture at the given time

WP = wilting point in per cent soil moisture.

This method for determining AW was the same as that reported by Peele, et al‡ for determining available water-holding capacity of soil, except M was substituted for field-capacity percentage§.

The daily evapotranspiration rate was calculated by using the following formula:

$$A=\frac{(B-C)+(D+E)-F}{G}$$

where A=evapotranspiration rate in inches per day

B=available soil moisture in inches at the beginning of the period

C=available soil moisture in inches at the end of the period

D=inches of rainfall during the period

E=inches of irrigation during the period

F=inches of runoff during the period

G=number of days in the period.

EXPERIMENTAL RESULTS

1 *Rate of Evapotranspiration*

Tomatoes. Soil-moisture records were begun June 3 under the tomatoes when the plants were about 16 in high. The daily rainfall and irrigation, the available soil moisture, and the periodic rates of evapotranspiration for the tomatoes are given in Fig. 1.

The soil on June 3 contained about 1.5 in of available moisture. This was 75 per cent of the 2.0 in of available water capacity in the soil to 18 in depth.

Only 2.88 in of rain fell during June and July. The irrigated tomatoes were watered 7 times, totaling 9.44 in. The soil moisture on these plots was maintained at a level of 25 per cent or greater of the available range, except for a day or two in early July when the wilting point was nearly reached before water was added.

The soil moisture under the unirrigated tomatoes declined steadily after June 3. A deficit of 0.6 in was recorded July 21. The rains that began on July 29 replenished the available moisture supply to only 1.20 in, or 60 per cent of the available water capacity of the soil.

The average rate of evapotranspiration for the entire period of June 3 to August 26 was 0.187 in per day on the irrigated plots. There was considerable variation from this average during this period. The maximum recorded was 0.31 in per day during the excessively hot dry period of July 16 to 24. A rate of 0.29 in per day was recorded June 17 to 25 when a series of light showers fell. No rain greater than 0.50 in per day fell during this time. Surface evaporation was high. The soil-moisture measurements indicated very little of this rain penetrated into the soil profile, and no runoff was measured. Low rates of evapotranspiration were recorded while the plants were small and again in the final days of fruit harvest.

The rains during the period August 4 to 14 caused some

‡Peele, T. C., Beale, O. W., Lesesne, F. F., and Carter, R. L.: Irrigation requirements of South Carolina soils, mimeograph, 1950.

§This project is indebted to A. W. Cooper (BPISAE), Auburn, Ala., and to O. W. Beale (BPISAE), Clemson, S.C., for determining the percentage of soil moisture at wilting point and at field capacity for the soils in this study.

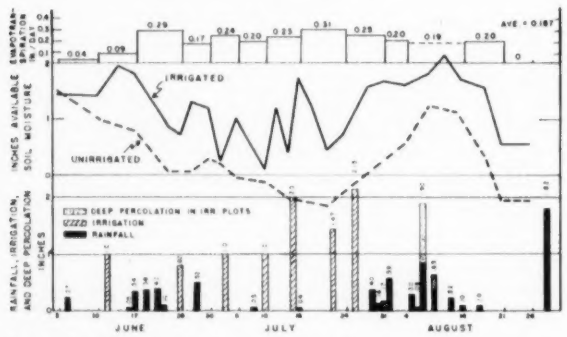

Fig. 1 Rainfall, irrigation, available soil moisture, and rate of evapotranspiration on tomatoes in 1952

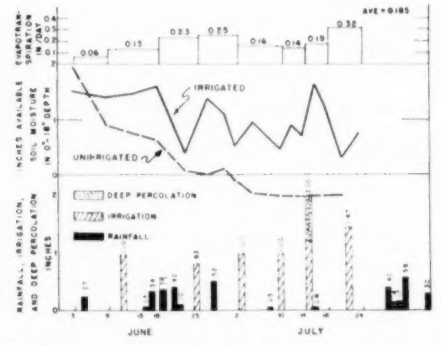

Fig. 2 Rainfall, irrigation, available soil moisture, and rate of evapotranspiration on pole beans in 1952

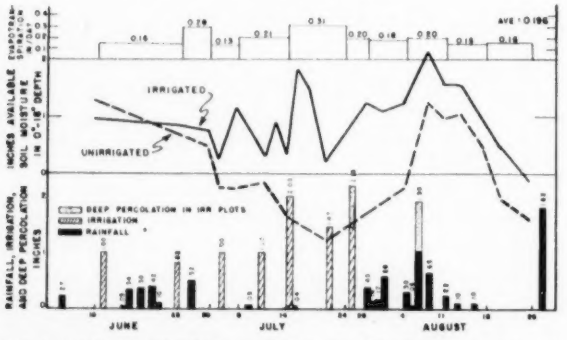

Fig. 3 Rainfall, irrigation, available soil moisture, and rate of evapotranspiration on cotton in 1952

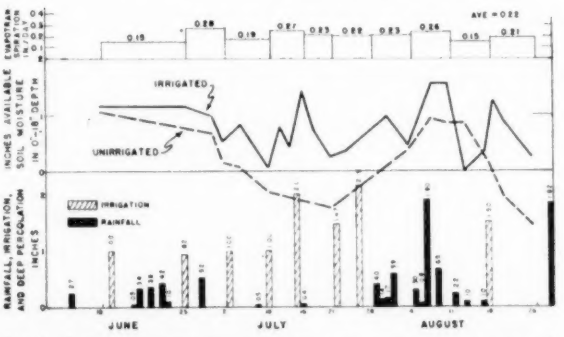

Fig. 4 Rainfall, irrigation, available soil moisture, and rate of evapotranspiration on corn in 1952

Fig. 5 (*Left*) Soil samples are being taken for measuring the distribution of roots under cotton. The soil was separated from the roots by elutriation • Fig. 6 (*Right*) The roots of cotton and corn were separated from the soil by elutriation, and the roots were recovered on the nests of screens

percolation below the 18-in depth. Evapotranspiration for this period was estimated at the average of 0.19 in per day.

The average rate of evapotranspiration by the unirrigated plants was 0.10 in per day. These plants drew soil moisture from a depth greater than 18 in to maintain life.

Pole Beans. Soil moisture records were started June 3 when the beans were about 12 in high and beginning to run on the stakes. There were 1.5 in of available moisture in the soil to the 18-in depth at that time. Records were completed on July 24 when rust killed the foliage on the plants.

Rainfall totaled 2.17 in during the period June 3 to July 24. Six irrigations, totaling 7.29 in, were applied to the irrigated plots during this period, as indicated in Fig. 2.

The average rate of evapotranspiration for the entire period June 3 to July 24 was 0.185 in per day on the irrigated plots. The maximum rate recorded was 0.32 in per day during the hot dry period July 18 to 24. Low rates of evapotranspiration were recorded while the plants were small.

The average rate of evapotranspiration by the unirrigated beans was 0.082 in per day. These beans drew soil moisture from below the 18-in depth to maintain life, but they were not able to set fruit.

Cotton. The soil-moisture record was begun on cotton June 10 when the plants were about 10 in high. The soil in the irrigated plots at that time contained 0.95 in of available moisture to the 18-in depth, or about 50 per cent of the 2 in of available water capacity. The soil moisture record ended on August 26. During the period of June 10 to July 28, only 1.90 in of rain fell, and the irrigated plots received seven irrigations, totaling 9.44 in (Fig. 3). Rainfall was fairly well distributed after July 29.

The available moisture in the unirrigated soil was completely exhausted to the 18-in depth by July 2. The plants drew some water from below the 18-in depth to maintain life, but made little growth during this period.

The average rate of evapotranspiration for the entire period June 9 to August 26 was 0.196 in per day for the irrigated cotton. A maximum rate of 0.31 in per day was recorded for the period July 14 to 24. The minimum rate of 0.13 in per day was recorded for the period June 30 to July 5. The evapotranspiration rate was below the average when the plants were small and again near the end of the season when the bolls were maturing. The first cotton harvest was on September 9.

The average rate of evapotranspiration by the unirrigated cotton was 0.113 in per day. The maximum daily rate was 0.34 in June 30 to July 2. The available moisture was completely exhausted from the top 18 in of soil during this period.

Corn. The corn was planted the third time on May 23. The two previous plantings were destroyed by crows.

Soil-moisture records were maintained for the corn from June 10 to August 26 (Fig. 4). The irrigated plots received 6.55 in of rainfall during that period, and 10.94 in of irrigation in eight applications.

The available soil moisture in the unirrigated plots was depleted in the 0 - 18-in depth on July 5 and remained there until the rains which began on July 29 replenished the water supply. These rains were too late for the corn to develop grain.

The average daily evapotranspiration rate for the period June 10 to July 26 in the irrigated corn was 0.22 in. The maximum recorded rate was 0.28 in per day and the minimum was 0.15 in per day.

The average rate of evapotranspiration for the unirrigated corn for the entire period June 10 to August 26 was 0.11 in per day.

2 Yields

Irrigation in 1952 produced outstanding yield increases over unirrigated crops. The yields, the increase with irrigation, and the least significant difference between treatments for the tomatoes, pole beans, cotton and corn are given in Table 1. These data show that differences in yields were highly significant for all crops.

We observed that the irrigated plants of these four crops grew vigorously and set fruit normally in 1952, even though average temperatures were at a record high during the dry period of late June and July. The abundant supply of soil moisture permitted the crops to produce yields in keeping with the limits of other productive factors.

The crops in the unirrigated plots grew well until the drought started on June 29. The plants then gradually

TABLE 1. YIELD OF POLE BEANS, TOMATOES, CORN, AND COTTON IN 1952

Crop	Irrigated	Unirrigated	Increase	Least significant difference, 0.05 level
Tomatoes, lb per acre	18,915	6,452	12,463	2036
Pole beans, lb per acre	5,183	541	4,642	1503
Cotton (seed and lint), lb per acre	2,534	742	1,792	520
Corn, bu per acre	70.1	10.6	59.5	21.8

depleted the available soil moisture. All of the unirrigated crops showed some signs of nutrient deficiency before the drought was broken by rainfall on July 29. Unirrigated corn appeared to have a greater nutrient deficiency than the other unirrigated crops. The ends of the corn blades turned yellow as the drought progressed.

As the irrigated cotton matured, signs of a definite potash deficiency were apparent. The leaves then shed from the plant in September and early October, facilitating picking the cotton.

Rains in August and September caused excessive second growth on the previously stunted unirrigated cotton. Picking the small yield of opened bolls in September and October was very difficult because of the heavy canopy of green leaves on these plants.

3 *Root Measurements*

The rooting depth of plants under irrigation practices has been a much discussed subject recently in the Southeast. The depth from which roots draw moisture from the soil affects the quantity and frequency of irrigation applications.

We planned to measure the distribution of the roots under the irrigated and unirrigated beans, tomatoes, corn and cotton in 1952. The excessive labor requirement and the time limitation for this work made it necessary that we limit these studies to just the corn and cotton. Even so, only duplicate measurements were obtained.

The procedure used is illustrated in Figs. 5 and 6. Soil samples were dug under representative plants in layers of 0 to 6, 6 to 12 and 12 to 18 in depth. The width of the sample was equal to the spacing between the plants and centered on a plant. It extended across the middle half the distance to the adjoining row on each side.

The entire soil mass was separated from the roots by elutriation in a 15-gal garbage can (Fig. 6). The roots flowed out of the can in the stream of muddy water, and were recovered on a nest of screens. The top screen of ⅛-in hardware cloth recovered nearly all the roots. A second screen of 1/16-in mesh recovered any roots passing the top screen. Gravels and large sand grains were left in the bottom of the can and did not clog the screens.

The quantities of roots measured are given in Tables 2 and 3 for the corn and cotton respectively.

The percentage distribution of these roots in the three soil depths was as follows:

Soil depth, in	Corn		Cotton	
	Irrigated	Unirrigated	Irrigated	Unirrigated
0–6	82.4	86.0	55.7	73.2
6–12	12.0	7.1	23.9	13.6
12–18	5.6	6.9	20.4	13.2
0–18	100.0	100.0	100.0	100.0

A few roots of both the corn and cotton extended below the 18-in depth in all samples. There was not time available for us to follow the roots deeper into the soil profile.

The above tabulation shows irrigation had little effect on the pattern of distribution of the corn roots. We believe that wetting the soil to the 18-in depth at each irrigation was enough for the corn.

The larger proportion of cotton roots at greater depths in the soil indicates there might be a possibility of applying more water at less frequent intervals for cotton than for corn.

TABLE 2. WEIGHT OF ROOTS UNDER IRRIGATED AND UNIRRIGATED CORN

	Sample	Unirrigated tons per acre*	Irrigated tons per acre*
Crown and brace roots	1	0.106	0.307
	2	0.093	0.405
	Avg.	0.100	0.356
Feed roots:			
0–6-in. depth	1	0.288	0.853
	2	0.333	0.412
	Avg.	0.311	0.632
6–12-in. depth	1	0.024	0.117
	2	0.028	0.068
	Avg.	0.026	0.092
12–18-in. depth	1	0.022	0.054
	2	0.028	0.031
	Avg.	0.025	0.043

*Oven-dry basis

SUMMARY

Research data on the daily rate of evapotranspiration are needed for a guide to when and how much irrigation water is needed during short drought periods in the Southeast.

Cooperative studies in 1952 by the Soil Conservation Service and the University of Georgia at Athens were designed to give data on the daily rate of evapotranspiration, crop yield response, and root distribution under irrigated versus unirrigated crops. The crops used were tomatoes, pole beans, corn and cotton.

The average daily rates of evapotranspiration per day were 0.187 in for tomatoes, 0.185 in for beans, 0.220 in for corn and 0.196 in for cotton. The maximum daily rates for these same crops were 0.310, 0.320, 0.280 and 0.310 in, respectively. The yield responses with irrigation were high from all crops. The average per acre yield for the four crops irrigated and unirrigated were: tomatoes, 18,915 and 6,452 lb; beans, 5,183 and 541 lb; corn, 70.1 and 10.6 bu, and cotton (lint plus seed), 2,534 and 742 lb. These differences in yield were highly significant for all four crops studied.

The distribution of roots under the corn and cotton was measured at depths of 0 to 6, 6 to 12 and 12 to 18 in. A few roots of all crops, both irrigated and unirrigated, penetrated below 18 in in the soil, but there was not sufficient time to determine the quantity nor maximum depth of penetration. Approximately 85 per cent of the corn feed roots were in the top 6 in of the soil. The proportion of the feed roots of cotton in the top 6 in was 65 per cent with irrigation and 73 per cent without irrigation. The larger proportion of the cotton roots at greater depths in the soil indicates that larger volumes of irrigation water might be applied at less frequent intervals to cotton than to corn.

TABLE 3. WEIGHT OF ROOTS UNDER IRRIGATED AND UNIRRIGATED COTTON

	Sample	Unirrigated tons per acre*	Irrigated tons per acre*
Crown and tap roots	1	0.086	0.243
	2	0.168	0.238
	Avg.	0.127	0.240
Feed roots:			
0–6-in. depth	1	0.185	0.110
	2	0.170	0.170
	Avg.	0.178	0.140
6–12-in. depth	1	0.029	0.071
	2	0.037	0.048
	Avg.	0.033	0.060
12–18-in. depth	1	0.037	0.053
	2	0.027	0.049
	Avg.	0.032	0.051

*Oven-dry basis

Possible Farm Applications of the Heat Pump

Chester P. Davis, Jr.
MEMBER ASAE

DURING the years following World War II, renewed interest in the heat pump has been apparent and a great deal of research and practical development has taken place. Agricultural engineers are interested in the development, particularly as it relates to possible applications on farms.

Year-round air conditioning using water, earth, and air as heat sources or sinks for the heat pump has progressed from the tailor-made experimental stage to the packaged units available on the market and installed in commercial establishments and homes. These are available for domestic air conditioning in many areas including of course rural areas where comfort is as much appreciated as elsewhere. The combination heat pump water heater and air conditioner has all but passed from the developmental stage and appears to be reaching the state where mass production in the immediate future may become a reality. Performance tests at Kansas State College have indicated a performance factor of 1.75 and a heating coefficient of performance of approximately 2.8 at a 145-F-outlet and 70-F-inlet, water-delivery temperature.

At least as early as 1947 engineers were thinking in terms of agricultural applications. C. P. Wagner of the Northern States Power Co.(1)* was pointing out usage for milkhouse heating in combination with a milk cooler. H. S. Hinrichs of Kansas Power and Light Co. and R. I. Lipper(2), director of the Kansas CREA research, were following a parallel path in some work with a combination milk cooler and hot water heater unit. Still other interest was being shown at Minnesota by Andrew Hustrulid and H. Ota(3) in a combination freezer and water heater. Purdue University(4) was also beginning a study of possible application on farms with emphasis on crop conditioning and had come to the generalized conclusion that simultaneous utilization of both the heating and cooling capabilities of the heat pump was desirable.

By 1948 O. W. Zastrow(5), technical standards division, Rural Electrification Administration, had presented a paper and written an article stating some of the possible farm uses for the heat pump.

The Farm Electrification Division (BPISAE), USDA, recognizing the significance of this work inaugurated a project in cooperation with the Kansas CREA and the agricultural engineering department of Kansas State College where some work was already in progress to determine the heat-transfer characteristics of soil. W. C. Trent and D. R. Kelly(6) set up a heat-transfer laboratory for determining basic transfer rates. A ground coil installation(7) was also built to measure heat flow to and from earth-imbedded direct-expansion refrigerant coils. Here transfer rates from clay and sandy soils varied from 3 to 4 Btu per hr per deg F per sq ft of exchanger area. In rejecting heat to the soil slightly smaller rates were observed. Work at other places and by other persons are too numerous to mention, but suffice it to say that a great deal of research and some application has taken place as a result.

It is perhaps significant to note that a majority of these workers were in the rural electric field. An example that points up the significance to those in this field is a 7½-hp water-type heat pump which during the year 1951 has required 17,261 kw-hr for farm home air conditioning and has provided a load factor of 20.5 per cent based on maximum demand for the year(8).

Also, in 1948 a 10-hp installation(9) to process popcorn to a desired moisture content had been made and was in operation at Princeton Farms in Indiana.

In England(10) an air-cooled refrigeration unit used to cool milk circulated this air over the condenser and passed it through hay to dry it.

Edgar S. Downs(11) of Battelle Memorial Institute, in a paper presented to the Farm Structures Division of ASAE, cited the above installations and methods and suggested it as a new approach to crop-drying problems.

Giese and Ibrahim(12) at Iowa State have suggested it as a possibility for use in the ventilation of animal shelters.

Building on earlier research, W. G. Buchinger(13), Detroit Edison Co., U. F. Earp and Leon Charity(14) of Virginia Polytechnic Institute, and continuing previous work, Andrew Hustrulid(15) have concentrated on simultaneous usage for cooling and heating.

There can be no doubt of the agricultural possibilities of heat pump equipment. The economic limitations are not easily established but must enter the picture.

Looking ahead to research work it seems desirable to define the now more or less clearly indicated lines of research and development for the purpose of coordination of effort and interchange of ideas between workers. There are at least five distinguishable lines of endeavor, though even these may be interrelated and others added. They are: (1) simultaneous utilization of the refrigeration and heating capacities for such purposes as milk cooling and water or air heating, (2) household year-round air conditioning, (3) air conditioning of livestock shelters, (4) curing and preservation of vegetables, fruits and other perishables, and (5) conditioning of certain seeds, grain and other agricultural products.

The application of the milk cooler also to heat the milkhouse has been said by W. G. Buchinger "to be probably the simplest, most economical and safest method known, but also the least accepted." It is a working reality, however, on some farms and can be expected to increase as the advantages are understood.

In the opinion of several research workers the possibilities of utilization of this same milk cooler for supplying water heating and its realization in commercially produced equipment is a step which may not be far away. The

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1952, as a contribution of the Rural Electric Division.

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*Numbers in parentheses refer to the appended references.

mechanics of doing the job are still controversial but the principle is clear. The almost certain imminence of production of the water-heater air-conditioning combination has added considerable impetus to research and development. Its merits are apparent from the standpoint of more efficient utilization of this piece of fundamental equipment.

Combinations of freezers with water or air heaters are being investigated. Here where used with freezers the maintenance of favorable coefficients of performance are not so easily obtained due to the relatively greater spread between evaporator and condenser refrigerant temperatures with the resulting lower coefficients of performance. Combinations with refrigeration temperatures of 40 to 50 F show more favorable coefficients of performance. This certainly is not to discourage such research, because by both cooling and heating there is again an efficient usage of equipment. The economics may be more marginal.

The second class, that of household year-round air conditioning, is an established fact. The value of pumped water for livestock consumption and limited lawn and garden irrigation is one factor in favor of using water as a heat source and sink. An adequate, economically available supply is not, however, always available. Units that use air as a heat source and sink with supplemental heat sources for peak conditions have become commercially available during the past year.

Air conditioning of livestock shelters with this equipment has not been attempted in this country so far as is known until recent planning and equipment for work was inaugurated at Purdue University with respect to broiler houses. Here one of the features of the equipment is the same as that of the smaller basement or other space dehumidifiers, that of being able to condense moisture from air in a space such as a stanchion-type dairy barn, laying or broiler house. Gases such as ammonia which are absorbed by the water vapor are removed in the condensate. The heat is retained within the space. It is not necessary to remove large amounts of moisture-laden air containing considerable heat to lower the humidity and prevent excessive condensation and attendant moisture problems. In a research project conducted in Sweden dehumidification was combined with the heating of a normally insulated five-room home using a design air temperature of +5 F. A stanchion-type barn located over 100 yd from the house with 10 to 15 dairy cows provided sufficient heat for maintaining the barn temperature above freezing and the home at normal comfort temperatures. The value of summer cooling with the equipment is subject to controversy though work in progress at the psychroenergetic laboratory at the University of Missouri and elsewhere will shed further light on this possibility.

The curing and preservation in storage of certain vegetables such as onions and sweet potatoes require at least two separate conditions involving both temperature and humidity control. In the case of sweet potatoes suberization and curing are promoted by high temperature (85 F) and relative humidity (85 per cent) during the first ten days of storage life. After that storage at 55 to 60 F and 80 to 85 per cent relative humidity is desirable. Using the same equipment and without moving the product, the heat-pump unit possibly with some auxiliary equipment is inherently capable of producing this effect. During winter storage some heating is also required in many locations, and the heat pump with its full automatic control and capability of either heating or cooling could perform this function.

More and more reports of work by private research agencies, the Refrigeration Research Foundation, state agricultural experiment station horticulturists, USDA storage and transportation personnel have pointed out the desirability of maintaining temperatures and humidities at certain optimum levels for maximum quantity and quality preservation. With some auxiliary humidification equipment and control these requirements could very probably be met.

The last phase of the application previously mentioned was in the conditioning of certain farm crops. Such an installation for conditioning popcorn, a crop of large cash income in southern Indiana, has been in operation at Princeton Farm at Princeton, Ind., since 1949. The objective was to condition air to a temperature and humidity that would correspond to a specified and desired equilibrium moisture content. The installation is shown schematically in Fig. 1. Moisture-laden air leaving the drying grain is pulled over a cold evaporator coil. Here it is cooled to and below the dew point and moisture is removed in the form of condensate. This dehumidified air is now passed over the condenser of the system and reheated. This consists of heat extracted at the evaporator and further work energy released in heat form by the fan and condensing unit in the work they perform. The conditioned air is now passed through the seed or grain to complete the drying cycle.

Uneven drying of the product in bulk can be prevented by adjustment of temperature and humidity of the air to correspond with the equilibrium moisture content desired. The attribute of being able to effect such control within limits is desirable for at least some farm products.

CLOSED-CYCLE CONTINUOUS DRYING SYSTEM

Theoretical studies of a closed-cycle continuous drying system conducted as part of a master's thesis at Purdue University(16) showed the following relations (Fig. 2) for units designed to operate to provide air at the same dry-bulb temperature but at different relative humidities. Condition 1 (58 per cent Φ) is for an approximate equilib-

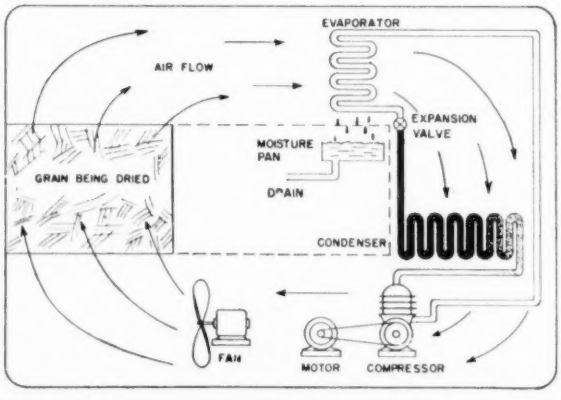

Fig. 1 Schematic drawing of closed-cycle, heat-pump grain drier at Princeton Farm, Princeton, Ind.

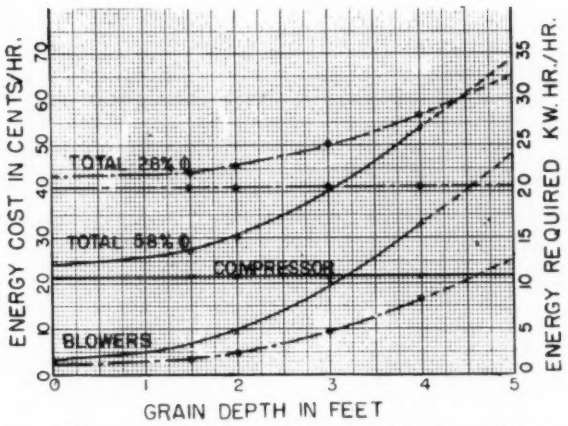

Fig. 2 Energy required for operating a continuous-type shelled-corn drier at 110 F and at a rate of 1,000 lb per hr (25-13.6 per cent, dry basis)

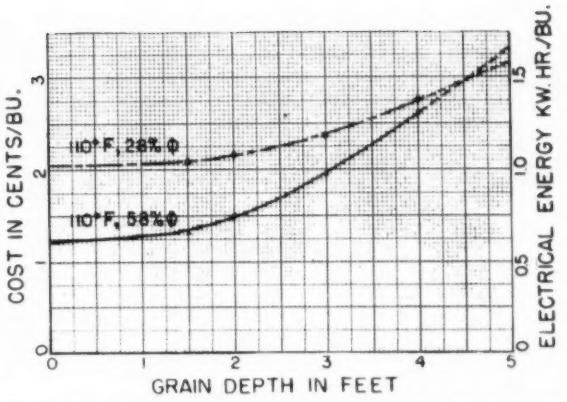

Fig. 3 Energy required and cost of energy per bushel for operating a continuous-type shelled corn drier — 1,000 lb of grain dried per hour (25-13.6 per cent, dry basis)

rium moisture content of 12.5 per cent while condition 2 (28 per cent Φ) would give a final moisture content of 8 per cent, if carried to equilibrium. For a continuous drier this would not prevent reaching the moisture content desired, but for bulk drying it would.

It will be noted that it requires considerably higher compressor energy input to produce the low humidity air, since the suction pressure of the machine must necessarily be lowered to obtain that level of dehumidification.

Using Hukill's(17) relations and choosing a particular rate of drying (1000 lb per hr) blower energy requirements are shown for an air flow of 31.2 cfm per bu at condition 1, (58 per cent Φ), and correspondingly less for condition 2, (28 per cent Φ). It will be noted that there could be a family of curves if different relative humidities are chosen for the drying air and that the depths of grain for which total energy requirements are similar would vary depending on the air conditions compared. This study presents a method for estimating the energy requirements for drying grain with specified air conditions and for arriving at an optimum design condition for the equipment.

In terms of operating economics in which we are in the final analysis basically interested, Fig. 3 shows these total electrical energy requirements for shallow depths of grain on a per bushel basis.

Mr. Downs in a similar study compares this system with a fuel-oil-fired drier and finds that, at 2c per kw-hr and 12c per gal, respectively, the cost per hour operation would be 2.7c for the closed-cycle heat pump and 3.3c for the oil-fired drier. The heating coefficient of performance of the heat-pump unit under these conditions was 4.3.

The conclusions were approximately similar for these two studies; that for cold weather drying 20 per cent less operational cost was required for the closed-cycle system.

Objectively of course the initial cost of equipment, grain handling and all other economic factors must be considered. No attempt has been made to do this to date, though it is expected that the initial costs of the closed-cycle system would be higher.

In general, the cost comparisons and advantages of securing a uniform specified moisture content have been favorable enough to build experimental laboratory equipment. Drying tests further than those to prove that grain can be dried to a relatively uniform specified moisture content have not been undertaken to date. Using this unit for the same dehumidifying purpose for warm-season drying versus using conventional methods of heating air and forcing it through the seed mass has not been investigated. By use of an air-to-air heat exchanger between the evaporator and condenser the efficiency of the drying unit could be increased and drying air of low humidity and relatively high temperature is feasible even under unfavorable drying weather conditions.

In summation, it is certain that the heat pump equipment has considerable possibilities in farm application, some of which are being realized and more are in necessary research stages.

The economic development of such applications will depend on how accurately the capabilities of this equipment are evaluated. Limitations are relatively high equipment costs, skilled service requirements and inability to furnish heat economically at high-temperature levels. However, where fully automatic operation over both the heating and cooling range is desired, where simultaneous usage of the heating and cooling potentialities can be realized, or where specialized conditions of temperature and relative humidity may be necessary, the heat pump in some cases offers worth-while advantages.

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Measuring Seepage from Irrigation Canals

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SEEPAGE from irrigation canals and ditches is a problem of great economic importance to irrigation agriculture. It has been variously estimated that one-third to one-half of all the water diverted for irrigation is lost through seepage in conveyance systems. With the increasing demand for water by agricultural and industrial interests in arid regions, it is increasingly important that measures be taken to reduce these losses. An accurate method of locating and determining the extent of seepage losses is requisite to adequate control practices. The high cost prohibits the use of lining or other conservation measures on an extensive scale, so that means of localizing seepage losses is necessary to effect the greatest conservation of water with limited funds.

Various methods have been proposed and developed for measuring seepage losses from irrigation systems. Israelsen and Reeve (2)*, Lauritzen and Israelsen (3), Rowher and Stout (6), and the U. S. Bureau of Reclamation (8), list and describe the more common direct methods of measuring seepage losses. Indirect methods which attempt to relate certain physical properties of the canal bed material to the amount of seepage from the canal have been proposed. These methods include the measurement of factors thought to be indicative of seepage losses as the texture of the canal bed material and ground-water fluctuation studies. The soil profile controls to a large extent the seepage from canals, but is influenced by various factors as depth to ground-water table or inhibiting layers and the topography of the area. At present the mechanical analysis of soils appears to be of value only in estimating probable seepage from canals. A study of the relationship of texture of the subgrade material to the seepage losses from canals indicates that the texture may be indicative of seepage losses in sandy soils overlying deep water tables†. The use of observation wells and piezometers for determining ground-water fluctuations are of value in determining the conditions under which the seepage measurements are made and may also be used to locate and estimate the amount of seepage from conveyance systems.

Of the methods proposed for measuring seepage from irrigation canals, all have certain limitations in accuracy, cost, or adaptability. At present it appears that no one method is adequate for determining seepage losses under all conditions. Of the methods developed, the USDA Salinity Laboratory meter has a number of desirable features and should theoretically give good results. Its advantages are that: (*a*) measurements are made under operating conditions at normal water levels, (*b*) losses are measured from small local areas which may locate and segregate regions of excessive seepage, and (*c*) the measurements can be made at practically any time without excessive labor or equipment costs. The meter has the limitation that measuring the losses from a limited area may require a considerable number of measurements to reliably indicate losses over a section of a canal and obviously the meter cannot be used to measure losses in most lined canals.

The ease with which the Salinity Laboratory seepage meter may be used and the advantage of localizing and delineating areas of greatest seepage has resulted in wide use of the seepage meter. The Salinity Laboratory meter and various modifications of this device have been used in seepage studies. Israelsen and Reeve (2), Carter (1), Meyers (5), Thurmond (7) Warnick (11, 12) and Wiggins (13) utilized the Salinity Laboratory meter and various modifications of this meter in studies comparing several methods of determining seepage losses. In general, the results were variable and inconclusive. In some studies there appear to be insufficient data and an inadequate analysis to justify drawing valid conclusions. Meerschiedt (4) investigated the effects of the design of permeameters and seepage meters and the depth of installation on seepage measurements. These results, based on a large number of measurements in several different soil types, point to the fact that much of the variation in seepage rate determined by the seepage meters and permeameters may be a result of the various depths of installation. The Bureau of Reclamation (9) made an investigation of the seepage losses from the canals and laterals on the North Platte Project in Wyoming and Nebraska in 1951. They determined seepage losses from a number of sections of the irrigation channels by the ponding method and by the use of

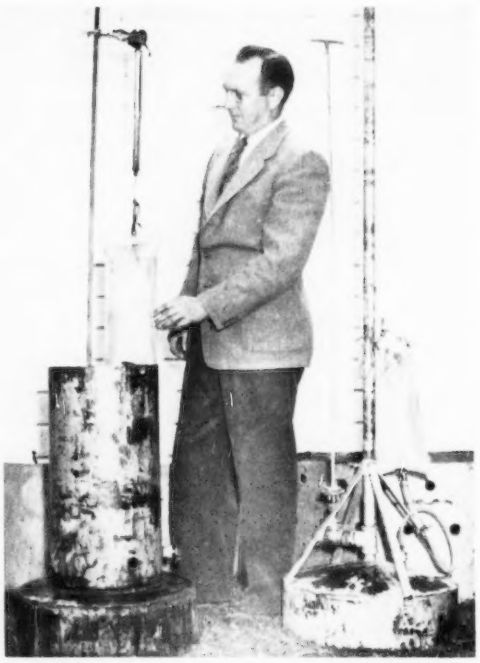

Fig. 1 Salinity Laboratory and Bureau of Reclamation-type seepage meters and the type of baffles used in the study reported in this paper

This paper, a contribution from the division of irrigation engineering and water conservation, Soil Conservation Service, U. S. Department of Agriculture, and the Utah Agricultural Experiment Station, was prepared for presentation at the annual meeting of the Western Society of Soil Science at Corvallis, Ore., June, 1952.

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*Numbers in parentheses refer to the appended references.

†Unpublished data.

seepage meters. Approximately 350 seepage-meter settings were made in the canal both during water deliveries and while ponding measurements were in progress. In general, the results obtained by the seepage meters were extremely variable. A comparison of the results from the use of the seepage meters and from the ponding tests indicated a variation in the seepage rate from 93 per cent less than to 285 per cent greater than the ponding method. From this extensive study they concluded that "Further correlation data and perhaps revision in the meters or changes in the technique are required before the seepage meter can be considered a reliable instrument for the measurement of seepage losses."

In the present study an attempt was made to determine the reliability of the seepage meters as a means of measuring the seepage losses from irrigation canals and ditches. The study was limited to a comparison of the results of the seepage meter and ponding methods under field conditions.

EXPERIMENTAL PROCEDURE

Seepage-meter measurements were made over five canal test sections on four operating canals. Seepage losses over three of these sections had been previously determined by the ponding method. Ponding measurements over the other two sections were planned but have not been completed.

A general procedure was followed in the seepage-meter studies in all of the areas. Measurements were made at intervals along the sections of the canals under study. The sections varied from 500 to 2,000 ft in length. In the short reaches measurements were made at approximate 100-ft intervals. Over the longer reaches measurements were made at intervals varying from 200 to 500 ft. Two types of seepage meters were used in the study: two standard Salinity Laboratory meters and four patterned after a modification of the Salinity Laboratory type developed by the Bureau of Reclamation in a recent study on the North Platte Project in Wyoming and Nebraska (9) (Fig. 1). Usually the six meters were used at each location or station within a reach, with two settings with each meter and two readings (i.e., two separate determinations of volume lost per unit time) at each setting. The meters were set at random across the canal bottom and on the side slopes. Settings were made several feet apart so that measurements at a single location were made over approximately 30 linear feet of the canal. Precautions were taken to install the meters in undisturbed areas of the canal bed, which had not been stepped on or otherwise disturbed by the operator.

The Salinity Laboratory-type meter described by Israelsen and Reeve (2) consists of a cylindrical base with a cone-shaped top having a small gate valve at the apex, an upper cylinder of smaller diameter is welded to the top of the base to serve as a baffle for protecting the bag and as a support for a rod used to support the bag during weighing. The base of the meter or the seepage cup enclosed an area of two square feet and was six inches in depth. The reservoir is usually a thin-walled plastic bag‡ which is connected to the base by plastic or rubber tubing. A 6,000-g spring balance is used to weigh the bag to determine quantity of water lost. The Bureau of Reclamation type has a similar base with a single 1-in pipe rising from the apex of the cone and braced to the outside edge of the base. The base of the meter enclosed an area of 2 sq ft. The sides of the seepage cup were 9-in in depth. The meters developed for this study were designed with cups 6-in in depth. The valve is attached to the stand pipe by a T-joint and is operated from above the water surface by an extension handle. This modification facilitates installing the meter in deep water and removes one objectionable feature, that of the operating of the valve as on the Salinity Laboratory meter under the surface in deep and usually cold water.

The meters are installed in the same manner by first opening the valve and then forcing the lip of the lower cylinder into the bed of the canal. The plastic bag is filled with water and held above the surface to expel the air from the tubing and the base of the meter. In certain locations in sandy soils the inside of the lip of the meter base was coated with heavy grease to prevent channeling down the wall of the meter. The plastic bags with a single outlet were filling by dipping, using a small funnel and a short length of tubing attached to the bag. The bag is attached to the tube from the base of the meter and then lowered below the surface and the air inlet valve at the base of the meter closed. A pinch cock is clamped on the inlet tube and the bag raised above the surface of the water a definite amount and weighed. The bag is then placed below the surface and the pinch cock released. After a timed period the inlet tube is pinched off, the bag raised and weighed as before. The loss in weight in grams (or cubic centimeters as the liquid is water) and the time is recorded. The location in the channel, the depth of the water adjacent to the meter, the temperature of the air and water and the initial and final weights of the bag and the initial and final time are recorded on an appropriate data sheet for each reading. Observation on the per cent cut and fill of the canal at the location, the variation of the water surface from normal, the design capacity of the canal, the soil type and the name of the observer are also recorded for each station.

BAFFLES USED TO PREVENT EROSION

In certain of the canals studied the sandy nature of the canal periphery and the high velocity flow resulted in considerable undercutting or erosion around the base of the meter and the resultant tipping or upsetting of the meter. In an effort to prevent this two types of baffles were used. One consisted of a ring of 16-gage galvanized iron approximately 3 ft in diameter and 18 in high with two rows of ¾-in holes near the top. Another type consisted of a sheet of 18-gage galvanized iron approximately 7 ft long and 14 in high (Fig. 1). The ring-type baffle was installed by inserting the bottom edge of the ring a short distance into the bed of the canal. A short length of strap iron bent to form a U-shape clamp on the top was used to anchor the ring. The seepage meter was then installed into the ring. The other type baffle was used by bending the metal sheet to form a rough V. This was placed in the canal and secured with a short length of strap iron as before. The meters then were installed a short distance downstream from the base of the V. The large area of both types of baffles increased the turbu-

‡Plastic bag manufactured by G. D. Richardson Mfg. Co., Fort Collins, Colo.

lence in the area adjacent to the baffles and it was difficult to obtain a seal around the base. As a result, the baffles were largely ineffective in controlling undercutting.

Whenever the meters were installed in a deposit of sand on the bed of the canal, serious undercutting occurred if the meters were left for any length of time. For short runs whatever limited cutting occurred is not considered to seriously affect the results. Whenever the meters were installed in a scoured area of the channel this undercutting did not occur very rapidly and the readings were considered to be valid. Regardless of whether undercutting occurred or not, the results were extremely variable on all meters at most locations.

The computations of the data obtained with the seepage meter are simple. The area enclosed by the seepage cup on all the meters was 2 sq ft. From this and the quantity of water lost from the flexible bag in a given period of time the seepage rate is easily determined. The seepage rates as measured by the seepage meters and the ponding method are expressed in cubic feet per square foot of wetted area per 24 hr. This unit of expressing the quantity of seepage loss is preferred in comparing losses between different canals which vary greatly as to the extent of the wetted area.

The seepage rate from the ponded sections is computed by plotting the canal cross sections at intervals within the ponded section from which the average width and wetted perimeter is determined. The width and the wetted perimeter at various elevations are determined to obtain the volume of water lost. The drop in the water surface with time was obtained by the use of continuous water-level recorders set at the lower end of each ponded section. The seepage rate is then readily computed from the volume of water lost per unit time, the width of the water surface, the length of the section and the wetted perimeter by the following simple formula:

$$\text{Seepage Rate} = \frac{\text{width} \times \text{length} \times \text{drop in water surface per 24 hr}}{\text{wetted perimeter} \times \text{length}} = \text{cubic feet per square foot per 24 hr}$$

The seepage rate versus depth of water in the section was plotted for purposes of comparison of the seepage with depth. The resulting curves were used in determining an average seepage rate from the ponding measurements for comparison with the average of the seepage meter measurements at comparable depths.

RESULTS AND DISCUSSION

A brief description and a summary of the results of the seeepage meter measurements on the various test sections follows:

Wilson Irrigation Company's North Branch Canal near Ogden, Utah. The canal through the test section is excavated in sandy soil ranging from fine loamy sands to very fine sandy loams. Through part of the reach studied, the canal is in a deep cut through a low sandy ridge and over the lower portion the canal traverses the brow of the sandy ridge. The canal bed through the test section is largely scoured with some deposition of fine silt on the bottom near the toe of the slopes. Through the lower portion the bed has scoured areas and fine to medium sand and silt deposits over much of the bottom.

The meters were installed at random within a limited area at each location. Precaution was taken to install the meters to a uniform depth of two inches, but due to the shifting sand deposits and the undercutting this was difficult to accomplish. The meters were finally installed to a depth of 4 to 6 in to help stabilize the meter and prevent rapid undercutting. The baffles described were used in an effort to stabilize the soils during the determinations, but they were largely ineffective.

A number of settings of each meter were made at each location with several readings of each meter at each setting. Whenever there appeared to be undercutting, entrapped air in inlet tube, faulty seals around the base of the meters, or other possibility of error, the results were discarded. The meters were frequently undercut and upset resulting in the loss of much data.

The data in general was extremely variable both between locations and between settings and readings of the same meter at the same location. This inconsistent variation persisted regardless of type of meter, location in the channel, the depth of water, or whether or not the baffles were used. More than 170 measurements were made in this test section but only 80 were considered valid. The seepage rate varied from a maximum of 9.31 to a minimum of 0.014 cu ft per sq ft per 24 hr, a range of one to approximately 65.

An analysis of variance of the data indicated that there was a significant difference between the locations within the section tested although soils appeared to be very much the same at each location. There was a highly significant difference between settings of the same meter at the same location. The readings at each setting of the same meter were highly variable, but this variation could not be tested by statistical analysis.

Eden Main Canal and the Farson Lateral, Eden Project (USBR) Eden, Wyo. Seepage meter measurements were made in two sections of the Eden Main Canal and one section of the Farson Lateral on the Bureau of Reclamation Eden Project, near Eden, Wyo., (10) with water flowing in the canal. Measurements were made over reaches which had been tested by the ponding method in the fall of 1950. Due to the sandy nature of the bed material and the high velocities (in excess of 3.5 fps) encountered in these canals, the meters were undercut and tipped as in the Wilson Irrigation Company's canal. The two types of baffles were again tried in an effort to prevent this difficulty but were unsuccessful. During this part of the study one of the seepage meters was modified to have a 9-in seepage cup. The modification was made to ascertain the value of deeper cups in preventing undercutting in sandy bed material. However, undercutting occurred more frequently with the 9-in cup than with the standard 6-in cup. One explanation might be that in certain instances the higher cup created greater turbulence around the base of the material with the resulting greater undercutting. Another factor considered was the possibility that installing the meter to a greater depth disturbed the soil to a greater extent, contributing to more rapid scouring. In view of the work of Meerschiedt, installing the cup to a greater depth would greatly affect the results. Thus it appears

there is need for an effective type baffle to prevent undercutting around the seepage cup and the base of the meters, if they are to be used successfully in streams with high velocity flow. A flat-screen-type baffle has been designed but has not been tested.

Due to the nature of the bed material in pond 1 of the Eden Main Canal, seepage meter measurements could be made only over a part of the section. The canal was excavated through shale material, which prevented the installation of the meter except in certain locations. The limited number of measurements and the limited location prevented any adequate analysis of the data in this section. Measurements were possible at all locations in the channel through pond 2, except on the lower side slopes and out a short distance from the toe line where the sandstone or shale protruded into the periphery of the canal. As in previous studies, the high velocity of stream and the sandy nature of the bed material resulted in undercutting and tipping of the meters. An analysis of the data indicated highly significant variations between settings of the meters within locations.

Seepage-meter measurements were made over a 500-ft section of the Farson Lateral through a section excavated entirely in Bridger shale which is believed to be very tight and highly impervious. The canal in this section was fairly uniform in depth and of irregular, approximately rectangular, cross section. The measurements in this section were more consistent, believed mainly due to the lower velocity in the canal and the more cohesive soil. An analysis of variance indicated the same disturbing variation between meter settings.

An analysis of the variance of the results of the seepage-meter measurements of pond 2 of the Eden Main Canal and the Farson Lateral indicated that there was no significant difference in the seepage from the sections although they are considered to be located in different soil types. There was no significant difference in seepage at the different locations within the section. There was a highly significant difference in seepage as measured by the duplicate settings of the same meter at the same location. This analysis based on a considerable number of measurements seems to cast considerable doubt on the reliability of seepage meters for measuring seepage losses from canals of the type studied. A comparison of the results obtained by the seepage-meter measurements as compared to the ponding measurements vary from 34 per cent less than pond 1 to 167 per cent greater than the rate by ponding from the Farson Lateral (Table 1). These comparisons are based on an average of the seepage-meter measurements. But since these measurements are so variable and not statistically significant, any comparisons made cannot be considered reliable.

Weber-Provo Diversion Canal, near Kamas, Utah. The seepage-meter measurements on the Weber-Provo Diversion Canal were very limited. Measurements were made in only one location near the downstream end of pond 2, with approximately 30 to 35 cfs flowing in the canal. An analysis of the limited data indicates that the seepage-meter measurements were less variable in this location than in some of the other canal sections measured. This may be attributed to the more cohesive soil and the lower water velocities than in the other operating canals. The analysis indicated a range of from 1 to 66 in the seepage rate. Since the measurements were made within a very limited area, this indicates the disturbing variations encountered, even in rather homogeneous areas. The data are inadequate to allow any valid inference of seepage losses from the section tested. In 25 measurements, the seepage as determined with the seepage meter, varied from a maximum of 2.02 to a minimum of 0.033 cu ft per sq ft per 24 hrs.

Ponding measurements were attempted on the Weber-Provo Diversion Canal during the period October 25 to November 1, 1951. Due to the seasonal low water in the Weber River and the high seepage losses in the canal above, the test sections the ponding studies were not completed. The results of the initial ponding measurements indicated that seepage rates were far in excess of those measured by the seepage meter.

CONCLUSIONS

From the initial investigations of the feasibility and limitations of the seepage meter for estimating seepage losses from specific sections of the canals described under the prevailing conditions it was concluded that:

1 The erratic and inconsistent results obtained by the seepage meter under certain of the test conditions casts considerable doubt on the reliability of this method for estimating seepage losses from irrigation canals.

2 The inherent variability in most natural soil materials will require considerable repetition of measurement to obtain any reliable estimate of such phenomena as seepage and permeability. It appears that any approach to a solution of the problem of determining seepage losses from canals from seepage meter data must be based on statistical methods and the number of seepage-meter measurements required to approach a reliable estimate of seepage from a canal may make the method prohibitive.

3 The operation of the seepage meter in canals excavated in cohesionless soils and high-velocity flow is extremely difficult. Undercutting of the seepage cup and tipping of the meters are of frequent occurrence.

(Continued on page 331)

TABLE 1. COMPARISON OF THE SEEPAGE RATES FROM THE EDEN MAIN CANAL AND THE FARSON LATERAL AS MEASURED BY THE SEEPAGE METERS AND BY THE PONDING METHOD

1	2	3	4	5	6	7	8	9
Canal Section	Number of meter readings	Seepage rate by meter			Rate by ponding	Variation		Ratio col. 5/6
		Maximum	Minimum	Average		Rate	Per cent	
		Cu ft per sq ft per 24 hr						
Eden Main Canal, pond 1	43	4.83	0.045	1.29	1.97	−0.68	−34.6	0.65
Eden Main Canal, pond 2	120	11.15	0.004	1.47	0.73	+0.74	+101.0	2.04
Farson Lateral	96	3.20	0.010	0.76	0.28	+0.48	+167.0	2.67

Electrification Changed the Face of Agriculture

H. S. Pringle
MEMBER ASAE

RURAL electrification has literally changed the face of American agriculture. Today nine out of ten farms in the country are electrified. Seventeen years ago, when the U.S. Rural Electrification Administration was created in 1935, that figure was reversed. Only one farm in ten was served with central station electric power at that time. In that same year the opinion was expressed by some that nearly every farm that could use electric power efficiently had already been electrified. The progress since that time has proven how wrong that statement was.

Today more than 1,000 REA borrowers are operating 1,200,000 miles of rural electric line serving 3,750,000 connected consumers. About 2¼ millions of these are farms and about the same number of farms are served by power companies and municipalities.

Today we know that the use of electricity increases farm production, but to what extent is difficult to gage. However, to demonstrate that it does increase production, let us examine the results of a survey the REA conducted on 41 Ohio and Indiana farms, before and after electrification. The average consumption per farm was 466 kw-hr per month. These farms had been using electricity for from one to five years. Taken altogether, their labor force was 6.3 per cent smaller at the time of the survey than it was just before they were electrified. This fact should be kept in mind while considering how the 41 farms increased their production.

First of all, there was a 27 per cent increase in the number of acres of land planted to crops and a 50 per cent increase in the amount of irrigated land. Production of crops and meat increased, 176 per cent in the number of acres of seed corn planted and 21 per cent in beef cattle raised. Some of the other increases were 46 per cent more milk cows, 55 per cent more laying hens and 57 per cent more chicks brooded, 130 per cent more chicks hatched, 109 per cent more turkeys raised, and 95 per cent more vegetables raised. In addition there was a sharp increase of 710 per cent in meat processing and of 500 per cent in apples marketed. Altogether these farms developed 19 new enterprises.

All this increased production was accomplished with a 6.3 per cent reduction in the labor force, as previously stated. Of course there were other factors, such as better farm management and increased mechanization of field work, which contributed to these results. But the use of electric service was the major change.

Somewhat similar surveys have been made in other parts of the country. The figures vary, of course, due to geographic and economic conditions and the extent to which electricity is used. But all of them, like the one mentioned, show in actual figures some of the tangible effects that rural electrification has had on farm production.

Many studies have been made of the effectiveness of electricity as a labor saver in farm production. One kilowatt-hour will do the work of 8 men on certain tasks. It will mix a ton of feed or lift 500 gal of water 100 ft.

As used to increase production, electrically heated hotbeds produce stronger plants, electric brooding of young animals can cut losses by about one-half, and the results in the case of irrigation are well known. Steers gain more weight, cows produce more and richer milk, and hens produce more eggs when water at the proper temperature is always available to them.

Electricity also aids production by reducing losses during the storing and handling of farm products and by improving their quality. The part that refrigeration plays is well known but progress in the reduction of losses of farm crops due to high moisture content or poor storage conditions has only begun. These losses are tremendous. We produced about 100 million tons of hay, 100 million tons of corn, and 100 million tons of small grain in 1951, but it has been estimated that 25 per cent of this production was lost on farms. At least 90 per cent of these losses are preventable.

Great progress has been made in the mechanization of field work, but we are told that, on the average, farmers spend about 50 per cent of their time working in and around the farm buildings. It is in this area, of course, that electricity can make its greatest contribution.

However, a comparison of the power used in industry with that used in farming would be startling to most of us. Industry has available about 7 hp per worker, while farms have available about 30 hp per worker, not including manual labor or animal power. Of this 30 hp, about 6 hp can be supplied better by electricity than by other means, but only about ½ hp is now being supplied by electricity. This means that there should be a twelvefold increase in the farm use of electricity for just doing the work that is now done by less efficient power.

The foregoing refers only to the present uses of power, not to the uses that can, and eventually will, be made of it. These new uses will make a considerable addition to that twelvefold increase.

The great majority of farmers are anxious to be shown how electricity can help them run their farms more efficiently. It has been estimated that already there are about 250 uses for electricity on the farm, outside the home. New uses are still being discovered and their application is limited only by farmers' knowledge of how to put them into practice, and by manufacturers' ability to make the equipment available at a reasonable price.

By and large, manufacturers have offered their cooperation to the rural electrification program. The extension of rural lines opened up new and profitable fields. Surveys indicate that for every dollar invested in rural power facilities, the farmer invests an additional $4.50 in wiring, plumbing, and electrical equipment.

But the farmer has difficulty in finding the right type of equipment and service to fit his particular operation. Large, nationally known manufacturers have not yet entered the field as fully as some leaders in rural electrification would like to see, and the job has more or less been left to small

An address before a special meeting of the American Society of Agricultural Engineers held in conjunction with the Centennial of Engineering Convocation at Chicago, Ill., September, 1952.

The author — H. S. PRINGLE — is extension rural electrification specialist, Extension Service, U.S. Department of Agriculture.

manufacturers to carry the load. In turn, these small manufacturers are plagued by lack of national distribution. They offer their products at the best prices possible, but they have trouble getting together with the ultimate purchaser.

Another factor is the lack of standardization of equipment on the farm. Much of the home electrical equipment is plug-in equipment for which standards have been established. This has allowed manufacturers to employ assembly-line methods of production.

Electrical farm production equipment, however, has no such set of standards to go by. Feed grinders, hay hoists, crop driers — to mention only a few — are not yet being produced in such quantities as to allow more attractive prices or more trouble-free operation.

At first, farmers tried to fill the void by converting their hand-operated equipment to electrical operation. This practice, while it showed the enthusiasm and needs of the farmer, left much to be desired in the direction of efficiency and safety.

Electrified farms today are faced with a difficult problem, mostly because of the fact that the shortage of farm labor is now more acute than ever before. Farm population dropped by nearly 7,000,000, or 23 per cent, from 1940 to 1950. During the twelve months from September, 1950, to September, 1951, the farm labor force decreased more than 350,000. Further reduction in farm man power is likely in the face of attractive industrial job opportunities and rising wage rates.

This means—and this fact cannot be stressed too much —that farmers today are being asked to produce 42 per cent more per agricultural worker than was produced just ten years ago. The country's population is increasing. Every day there are 7,400 additional people to feed in this country. This means that 15 additional tons of food are needed every day if our people are to continue to eat as they are eating now.

In conclusion, following is a summary of how the value of electric power on the farm increases day by day:

1 Electricity is available on most farms.

2 Agricultural production is the highest it has ever been, but must go higher.

3 Electricity offers the greatest potential for obtaining the necessary increases.

4 Agricultural engineers have a tremendous responsibility, not only in the development of new uses and equipment, but also in showing farmers how to apply electricity to the jobs they are already doing.

5 While progress in the efficient use of electricity in agriculture has been amazing, we have actually only scratched the surface.

Rural electrification is now recognized as a vitally important part of our national defense effort and of our peacetime economy.

Farm Applications of Heat Pump

(Continued from page 325)

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Measuring Irrigation Seepage

(Continued from page 329)

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Pressure Control on Individual Sprinklers

C. N. Johnston
MEMBER ASAE

THE problem of pressure loss due to friction within the line inherent in all sprinkler irrigation systems can be met quite well as a rule by providing adequate pipe sizes. But where the terrain is rolling, certain sprinklers along a lateral will surely need pressure regulation to perfect the pattern and equalize the distribution. For this reason it appears that pressure regulators applicable at each sprinkler that needs one is the solution. This seems to require a small, simple, sensitive device incorporated into the body of, or on, the supply line immediately below the sprinkler itself.

On the basis of this reasoning, in 1950 it was decided by the author to investigate the possibility of making a device to control the pressures for or in sprinklers. About the same time L. T. Coulthard (Member ASAE) from Alberta, Canada, became a graduate student in the irrigation department of the University of California at Davis, with an interest in sprinklers and an idea of controlling the flow to the nozzles by using the supply stream velocity.

We canvassed this idea as well as the possibility of metering the flow some way so as to maintain constant pressure at the sprinklers, but neither method could be developed at the time. A third and direct method of control was obvious, using fluctuations from the desired working pressure as a means of energizing a valve, so that when the pressure at the nozzles went below some fixed value more water from the supply would be admitted, and vice versa. A balanced valve was necessary so unequal pressure from supply to nozzle would not become a factor in the control. Mr. Coulthard went ahead with the construction and testing of the first of these direct-acting valves sketched out by the author, while the latter built and tested a series of models with the assistance of the laboratory machinist.

The whole series works remarkably well. All are immediately sensitive to small changes in nozzle pressure even when the supply pressure is allowed to fluctuate widely. A big advantage of these controls is that they require very little machining, can be made from stock brass rod and tubing, and are sensitive, light, compact, and cheap to produce so they can be incorporated into or just below a sprinkler. More recently the author has produced a valve which has a Venturi throat incorporated into it. Differential head in the Venturi is used to actuate the valve and thereby control the pressure behind the nozzles located just beyond the Venturi assembly. This valve combines velocity and metering principles with pressure control. Following is a description of a selected group of these conceptions which are offered to readers of AGRICULTURAL ENGINEERING for consideration:

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author — C. N. JOHNSTON — former irrigation engineer, University of California, Davis.

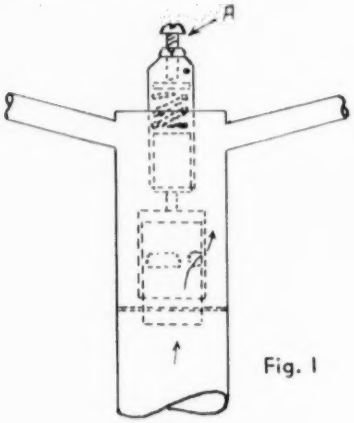

Fig. 1

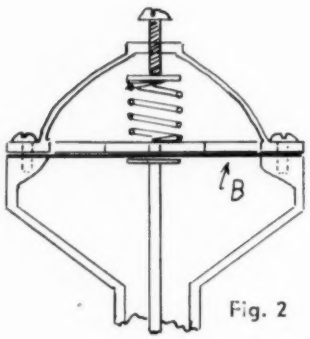

Fig. 2

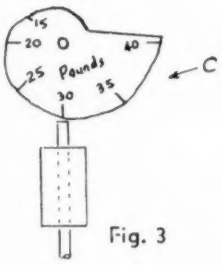

Fig. 3

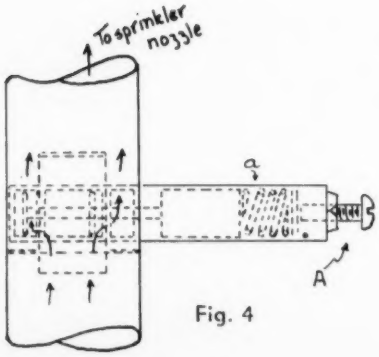

Fig. 4

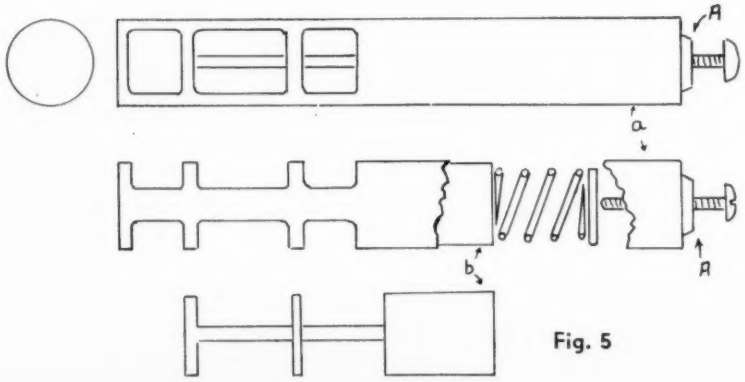

Fig. 5

Fig.1 is a sleeve-type valve mounted in the sprinkler body proper and centered in a retaining ring disk that seals off the flow from below. The outer cylinder operates a spring-loaded plunger that responds to the desired pressure for the sprinkler nozzles only. The adjustment screw A with the spring below permits manual setting to the desired pressure. The ports in the sleeves, which are relatively loose fitting, are elongated so that they do not have to register exactly from sleeve to sleeve.

In the valve in Fig. 2 is a diaphragm (B) with suitable mounting. The desired pressure on the nozzles forces the diaphragm against the spring load and the correct pressure can be maintained by adjustment of the screw.

Fig. 3 shows a cam so shaped that as it is turned it loads the spring, as in Figs. 1 and 2, to the desired pressure setting as indicated on the scale of the cam. Figs. 1, 2, and 3 are suitable for regulators operating directly on the desired operating pressure for the nozzles.

Fig. 4 and 5 show details of a side-mounted balanced valve that operates in a sort of cartridge that is pushed into a cage shown in the center of Fig. 4. The desired operating pressure is fixed with set screw (A) and the operating pressure affects plunger (b) directly. The disks on b provide a balanced valve when mounted in the ported outer cartridge (a). This valve operates directly on the desired nozzle pressure.

By providing piping or other connections at the proper locations, a control valve can be used similar to Fig. 6. Pipe connection 3 would be the contact with the desired operating pressure area of the sprinkler. Pipes 1 and 2 can be used by proper connections to effect the desired control as shown in Figs. 7 and 8.

In Fig. 7 the valve is Fig. 6 shown attached properly to make the inner sleeve of the sleeve valve with its suspended weight respond to fluctuations in supply pressure so as to maintain constant discharge pressure on the sprinkler nozzles so long as supply pressures exceed nozzle pressure requirements.

Fig. 8 is another application of the use of the valve in Fig. 6 but with the body of valve in Fig. 6 not shown. Here, when the pressure supplying 3 exceeds the desired value, the plugger in Fig. 6 is driven back far enough to permit flow from 2 to 1. This allows high-pressure water to flow to the top of the weighted cylinder forcing it down to obscure the ports in the outer cylinder reducing the pressure on 3.

Fig. 9 is a departure to a degree from some of the previously described valves in that a Venturi throat is used to create differential pressure (Hp and Lp, high and low pressure, respectively). This valve becomes in effect a velocity operated control, the Hp area above the central separating diaphragm causing the Venturi to move up and obscure the supply ports that register from inner to outer sleeves otherwise. The small weep hole in the bottom of the Venturi cylinder provides pressure balance here, and the cane-shaped tube looking into the Venturi discharge stream provides the high-pressure values above the separating diaphragm.

Viewpoint and Recognition

WHERE are the names of the engineers who executed the design and construction of the Pyramid of Cheops, the Taj Mahal, the Mausoleum of Semiramis, the Woolworth Building, the Empire State Building, the Rockefeller Plaza, the George Washington Bridge? Why are not their names, like those of the author, artist, doctor and lawyer identified with the work of their brain or hands?

It is because the engineer has not emphasized his human relationship with his work. He looks upon his work as an end in itself rather than as a link in the chain of human progress.—From Professional Postscripts in *American Engineer* for April, 1953.

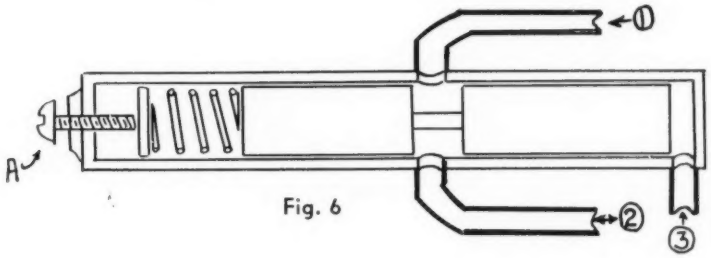

Fig. 6

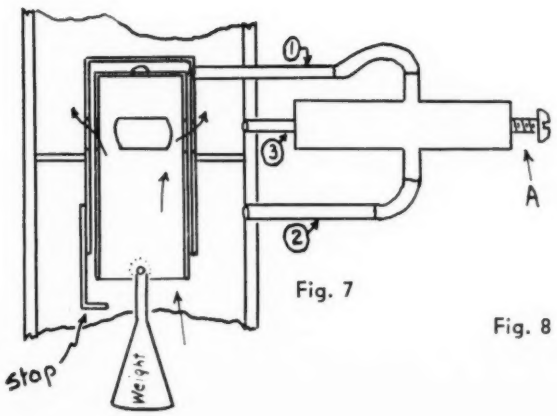

Fig. 7

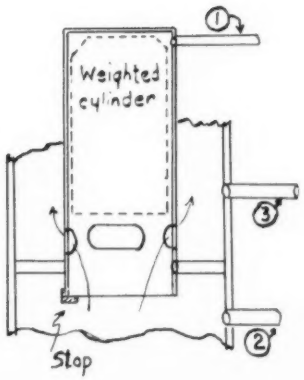

Fig. 8

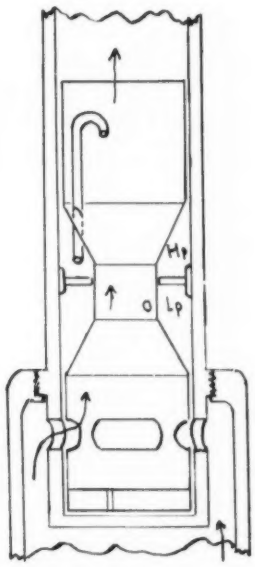

Fig. 9

NEWS SECTION

ASAE Meeting Plans for Pittsburgh

JUNE 14 through 17 have been packed with a wide variety and selection of activities for members and guests attending the 46th annual meeting of the American Society of Agricultural Engineers at Pittsburgh.

Arrivals, early registration, entertainment, and meetings of the Council and Cabinet on June 14 will set the stage for the opening of the technical and general sessions June 15.

Concurrent sessions of the technical divisions will be held on Monday and Tuesday forenoons; general programs on Monday and Wednesday afternoons, and special tours Tuesday afternoon and Wednesday forenoon.

The annual business meeting of the Society will follow its Monday afternoon general session. A "sponsors' party" has been scheduled for that evening, beginning at 6:30.

Concurrent special group programs, committee meetings and round tables will occupy Tuesday evening. Most of them will start at 8:00 p.m., but a student group dinner sponsored by the Farm Equipment Institute is scheduled for 5:45 p.m.

The program sponsored annually by the Committee on Extension will be one of the features of the evening. Extension exhibits will be open to inspection in the Allegheny Room throughout the meeting.

Wednesday evening is reserved for the ASAE Annual Dinner, the climax and concluding event of the meeting and the Society year.

Meeting headquarters, registration, and sessions will be on the 17th floor of Hotel William Penn.

Registration is scheduled to start at 1:00 p.m. on Sunday, June 14. The Sunday evening supper and entertainment have been set up with plans to handle a growing group of early arrivals.

GENERAL SESSIONS

J. B. Stere, chairman of the Meeting Committee, will call the opening general session to order at 2:00 p.m. Monday. B. P. Hess, chairman of the Committee on Arrangements, will follow with announcements pertinent to the balance of the three days. Chairman Stere will then call upon ASAE President Ivan D. Wood for the president's annual address.

The second general session, on Wednesday afternoon, offers a program sponsored by the College Division. F. R. Jones, chairman of the division, will preside. "How Not to Present a Technical Paper" will be illustrated by L. N. Rowley, Jr., editor of *Power,* and an authority on the subject. "Employment of College Personnel by Industry," is to be discussed by M. M. Boring, General Electric Co. W. C. VanDyke, Caterpillar Tractor Co., will present "Postgraduate Training Courses in Industry."

POWER AND MACHINERY PROGRAM

R. L. Worrell, chairman of the Power and Machinery Division, will call it to order at 9:30 Monday forenoon for consideration of "Adaptation of Semisolid Tires to Farm Requirements," by J. D. Berwick, Goodyear Tire and Rubber Co.; "Recent Developments in Potato Harvesting and Handling Equipment," by A. H. Glaves, U.S. Department of Agriculture; and "Mechanical Handling of Potatoes in Storage," by H. D. Bartlett and R. O. Martin, University of Maine.

A panel discussion on "Farm Equipment Steels" is featured on the Tuesday forenoon program, with Mr. Worrell and G. M. Eveleth, vice-chairman of the Division, alternating as presiding chairmen. Different viewpoints will be represented by members of the four-man panel as follows: "The Harvesting Machinery Engineer's Viewpoint," by C. J. Scranton, Allis-Chalmers Mfg. Co.; "The Tractor Engineer's Viewpoint," by F. C. Ewert, Deere and Co.; "The Tillage Implement Engineer's Viewpoint," by W. C. Bliesener, International Harvester Co.; and "The Steel Manufacturer's Viewpoint," by H. W. Browall, Inland Steel Co. A question and answer period will follow these presentations.

SOIL AND WATER PROGRAM

Features on the Monday forenoon soil and water program include "Relocation to Drains Required by New Road Locations," by H. N. Luebcke, Soil Conservation Service; "Culverts as Water Runoff Measuring Devices," W. O. Ree, Soil Conservation Service, and F. R. Crow, Oklahoma Agricultural Experiment Station; "American Water Law: Some Implications with Respect to Soil and Water Conservation," by C. E. Busby, water law consultant, Berkeley, Calif.; and "Results of Drainage Research in Eastern Carolinas," by E. G. Diseker, Soil Conservation Service. G. E. Ryerson, chairman of the Soil and Water Division, is to preside over this session.

ASAE Meetings Calendar

June 15 to 17—46TH ANNUAL MEETING, Hotel William Penn., Pittsburgh, Pa.

August 31 to September 2—NORTH ATLANTIC SECTION, Long Island Agricultural and Technical Institute, Farmingdale, L. I., N. Y.

December 7-9—WINTER MEETING, Edgewater Beach Hotel, Chicago, Ill.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Michigan

The Tuesday forenoon session, with A. J. Wojta, vice-chairman, presiding, will offer presentations on "Utilizing Climatological Data to Evaluate Irrigation Needs?" by Evan R. Allred, University of Minnesota; "Irrigation in Michigan," by E. H. Kidder, Michigan State College; "Runoff from Conservation and Non-Conservation Watersheds," by Ralph W. Baird and John A. Allis, Soil Conservation Service, and "Extension Work in Soil and Water Conservation," by S. P. Lyle, U.S. Department of Agriculture.

FARM STRUCTURES PROGRAM

D. P. Poor, chairman of the Farm Structures Division, will open its Monday forenoon session by calling for a "Report of the Committee on Farm Structures Research," by S. A. Witzel, University of Wisconsin. Papers to follow include "Self-Feeding of Forage," by C. H. Reed, Rutgers University; "Loose-Housing Dairy Barn Arrangement," by B. F. Cargill, Michigan State College; and "Time and Energy Studies on Milking in Loose Housing Dairies," by L. L. Boyd and W. H. Morris, Cornell University.

Tuesday forenoon the Division will collaborate with the Rural Electric Division in a joint program reported below.

RURAL ELECTRIC PROGRAM

"Automatic Feeding of Farm Livestock," by R. H. Wileman, United Cooperatives Laboratory, has been scheduled for first attention by the Rural Electric Division. A. H. Hemker, chairman, will preside. "Developments in the Automatic Feeding of Poultry," by A. E. Waterman, James Mfg. Co., will continue this line of thought with a slight shift of emphasis. To cover another major electrification interest, Leslie M. Barton, Diesel Power, Inc., will present "Latest Developments in Frost Protection."

JOINT PROGRAM

Mutual interests of the Farm Structures and Rural Electric Divisions to be emphasized in their Tuesday forenoon joint session, include "Dairy and Poultry Ventilation Analysis," by W. J. McGoldrick, Jr., Minneapolis-Honeywell Regulator Co.; "Flow Patterns of Air Through Grain During Drying," by Tappan Collins, Great Lakes Steel Corp., Xzin McNeal, University of Arkansas, and W. V. Hukill, U.S. Department of Agriculture; "New York Hay Drying Conference Experiment," by J. H. Oliver, General Electric Co.; "Drying Hay with Prefabricated Ducts," by I. R. Fisher, Clay Equipment Co.; and "Methods of Studying the Drying Pattern in Hay and Grain," by M. E. Singley, Rutgers University. N. H. Curry and E. T. Swink, vice-chairman of the two divisions, will alternate in presiding.

STUDENT GROUP PROGRAM

Student group sessions have been scheduled to be held concurrently with those of the technical divisions. On Monday forenoon Morris E. Schroeder, president, National Council of ASAE Student Branches, will preside over a session featuring "Welcome to Pennsylvania," by John E. Nicholas, Pennsylvania State College; a roll call of student branches; "After Graduation, What?" by Orval C. French, Cornell University; "Opportunities for the Graduate Engineer in Industry," by K. L. Pfundstein, Ethyl Corp.; and "The Why of ASAE Student Branches," by C. L. Zink, Deere and Co., chairman ASAE Committee on Student Branches.

Tuesday forenoon Wesley E. Harris, vice-president of the National Council of ASAE Student Branches, is to preside. He will first call for nominations for officers for the year 1953-54. The "Annual Report from ASAE Headquarters on Student Affairs" is to be presented by Frank B. Lanham, assistant secretary, ASAE. Informal reports and discussion of student branch activities during 1952-53 will be led by John B. Nichols, secretary, National Council of ASAE Student Branches. *(News continued on page 336)*

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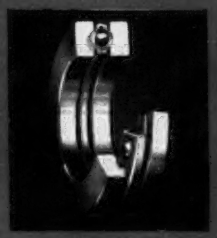

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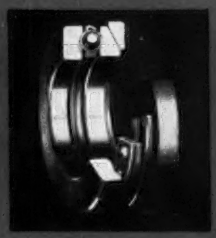

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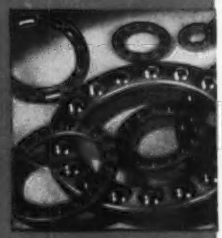

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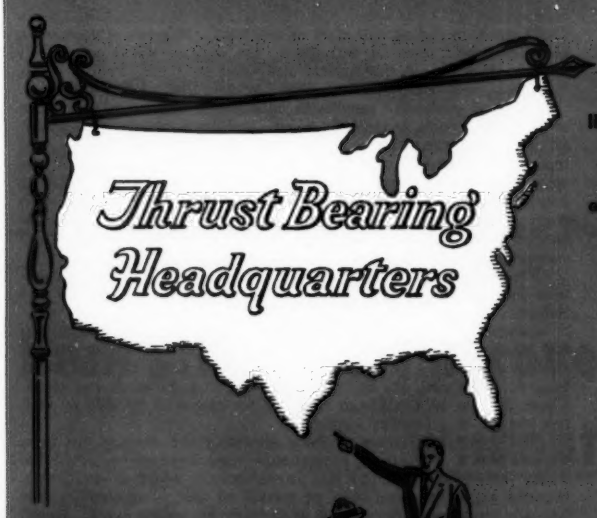

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NEWS SECTION *(Continued from page 334)*

In the afternoon the students are scheduled for a conducted tour of Mellon Institute and the University of Pittsburgh.

At the FEI dinner for the students and student branch faculty advisers that evening F. P. Hanson, chairman, Research Committee, Farm Equipment Institute; will preside.

I. D. Wood, president of ASAE, will address the students on "Expanding Horizons." Next on this program, A. E. W. Johnson, vice-president and director of engineering, International Harvester Co., will address the group on "What the Farm Equipment Industry Expects of the Graduate Engineer."

A color movie on "Development of a New Tractor and Implement Hitch" will be presented with comments by E. W. Tanquary, president-elect, ASAE.

The program for this session will close with C. K. Beeman, chairman, Committee on FEI Trophies, announcing the awards of those trophies for 1953.

A concluding student session Wednesday afternoon will feature a review and discussion of the 1953 FEI Trophies Competition and an election of officers for the National Council of Student Branches for 1953-54.

SPECIAL FEATURES

Among the Tuesday evening programs, the College Division offers an open meeting to be presided over by L. W. Hurlbut, vice-chairman of the Division. A symposium on graduate instruction will feature contributions on "Objectives and Standards," by Andrew Hustrulid, University of Minnesota; "Analysis of Graduate Instruction Programs," by F. W. Peikert, University of Maine; and "Graduate Instruction from Industry's Viewpoint," by D. C. Heitshu, Deere and Co. "Methods of Informing Precollege Students of the Requirements and Opportunities in Agricultural Engineering" will be presented by H. V. Walton, Pennsylvania State College.

Other features of the meeting will be announced in more detail shortly before or during the gathering at Pittsburgh.

Beeman Heads Iowa-Illinois Section

C. K. BEEMAN, assistant product engineer, J. I. Case Co., Burlington, Iowa, was elected the new chairman of the Iowa-Illinois Section of the American Society of Agricultural Engineers at the annual meeting of the Section held in East Moline, Ill., on April 24. He succeeds D. O. H. Miller of the French & Hecht Division of Kelsey-Hayes Wheel Co. Other officers elected at the meeting include two vice-chairmen, C. S. Morrison, chief engineer, product development department, Deere & Co., and M. E. Weakly, layout draftsman, engineering department, East Moline works, International Harvester Co. The newly elected secretary-treasurer of the Section is Roy E. Harrington, assistant product engineer, product development department, Deere & Co. The section also elected a steering committee of three members consisting of W. E. Knapp, Minneapolis-Moline Co.; H. V. Hansen, Hansen Bros., and W. P. Oehler, John Deere Planter Works.

Lately the Section has been quite regularly breaking its attendance records. A total of 134 ASAE members and guests took part in the conducted tour of the East Moline works of the International Harvester Co. and 174 attended the Section dinner meeting.

The meeting opened on the afternoon of April 24 with plant tours which were completed late in the afternoon and were followed by a professional program which included a talk on the registration of professional engineers by A. D. Spicer, secretary-treasurer, National Society of Professional Engineers. The second speaker on this program was R. R. Raney, divisional chief engineer, farm equipment division, International Harvester Co., who spoke on the subject "Why Cultural Education for Agricultural Engineers?" The afternoon program closed with a panel discussion on the subject "Industry's Answers to Student Engineers' Questions," with C. S. Morrison of Deere and Co. as moderator.

The afternoon program was followed by the Section dinner at the Ship's Wheel Club in East Moline, at which E. L. Hansen of Hansen Bros., and a vice-president of ASAE, was the featured speaker, his subject being "The Farm Implement Dealer's Responsibilities and Contributions to Agriculture."

Eleven students in agricultural engineering from Iowa State College and six students from the University of Illinois were guests of the Section at the meeting. At the Section's business meeting it was voted to send each of the two student branches of the Society at these institutions a sum of $50 to be used toward defraying expenses of students attending the 1953 ASAE annual meeting to be held in Pittsburgh in June.

Southwest Section Names Hobgood

PRICE HOBGOOD, professor of agricultural engineering, A & M College of Texas, was elected chairman of the Southwest Section, American Society of Agricultural Engineers, at the yearly meeting of the Section held at Oklahoma A & M College, Stillwater, April 10-11. He succeeds Eugene C. Buie, zone conservationist, Soil Conservation Service. A. H. Gray, Jr., head, rural development department, Southwestern Gas and Electric Co., was named vice-chairman, and W. T. Wheeler, regional product specialist, International Harvester Co., secretary-treasurer.

A registration of 134, including 29 student representatives, was the best attendance in the Section's history. Attending the annual dinner, at which Chairman Buie presided, were 116 agricultural engineers, their ladies and guests. Entertainment was provided by a student group from the College, following which E. W. Schroeder introduced the featured speaker of the evening, Dr. C. Dan Procter, president, Oklahoma College for Women. Dr. Proctor gave an inspirational message on the human tendency to wish for the "good old days" rather than exhibiting vision and falling in step with sound, progressive movements.

The facilities of the spacious Student Union and Union Club buildings on the campus provided unusually fine accommodations for the meeting.

At the business meeting on Saturday morning, the Section voted to hold the 1954 meeting jointly with the Southeast Section in Dallas. The latter group customarily meets in conjunction with the Southern Association of Agricultural Workers in February.

Agricultural Engineers Invited

AGRICULTURAL engineers attending the 1953 ASAE Annual Meeting at Pittsburgh in June are invited to visit the Soil and Water Conservation Experiment Station near Coshocton, Ohio.

The station, operated by the U.S. Soil Conservation Service in cooperation with the Ohio Agricultural Experiment Station, covers 1,047 acres, including 470 acres of cropland, 270 acres of permanent grass and 307 acres of woodland. Its shallow silt loam soil is typical of much of the agricultural land in Ohio, Pennsylvania, West Virginia, Kentucky, southern Indiana, and southern Illinois.

Items of particular interest to agricultural engineers to be seen at the station include rainfall, runoff, and erosion-measuring installations, lysimeters, contour fences, barn with hay drier and silo, and Station headquarters and soils laboratory. Of more general and agricultural interest are plantings of birdsfoot trefoil, a multiflora rose fence, pasture seedings, contour strip cropping, reforestation on steep land, field stacks of chopped and long grass silage, and the lookout tower giving a bird's-eye view of much of the station and surrounding country.

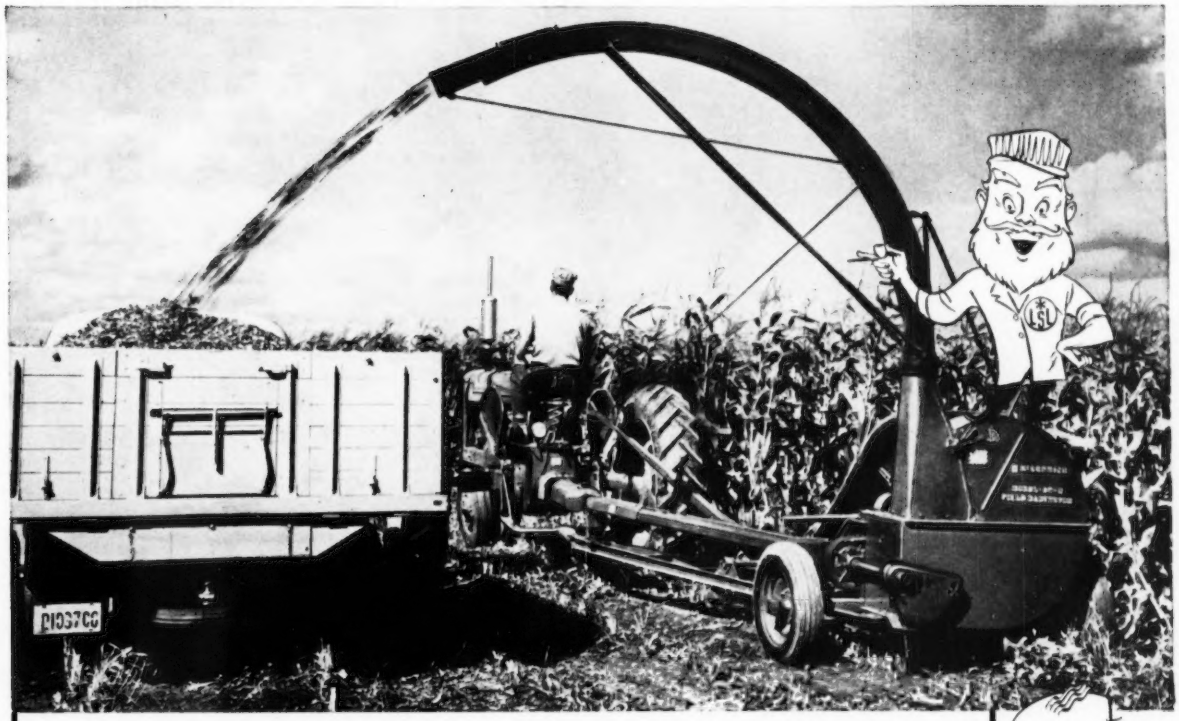
Visitors from all over the United States and many other countries have studied the installations and research program of the station.

Located 11 miles northeast of Coshocton on Ohio Route No. 621, the station will be found to be little if any out of the way for visitors driving to or from Pittsburgh across Ohio on U.S. Route Nos. 6, 20, 22, 30, 36, 40, or 50, or using U.S. 21 north and south. Those driving to Pittsburgh from points east will be able to visit the station in a one-day side trip.

The special invitation to those attending the meeting has been extended by L. L. Harrold, project supervisor and member of ASAE. Those who plan to accept this invitation are asked to notify Mr. Harrold as to expected time of arrival so that arrangements may be made to show them as much as possible during their visit. Postal card or letter notice may be addressed to L. L. Harrold, U.S. Soil Conservation Service, Coshocton, Ohio.

(News continued on page 338)

Bird's-eye view of the U.S. Soil Conservation Service Experiment Station near Coshocton, Ohio



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NEWS SECTION (Continued from page 336)

Borden Heads Rocky Mountain Section

JAMES W. BORDEN, vice-president and general manager, Eversman Mfg. Co., Denver, Colo., was elected the new chairman of the Rocky Mountain Section of the American Society of Agricultural Engineers at the first annual meteing of the Section held April 10 and 11 on the campus of the University of Wyoming at Laramie. He succeeds Guy O. Woodward, extension irrigation specialist, University of Wyoming, the Section's first chairman.

The new vice-chairman of the Section elected at the meeting is J. E. Christiansen, dean of the school of engineering and technology, Utah State Agricultural College. Norman A. Evans, assistant professor of civil engineering and assistant irrigation engineer, Colorado A & M College, was elected the new secretary of the Section, and William E. Code, associate irrigation engineer, also of Colorado A & M College, was elected chairman of the program committee for the 1954 meeting of the Section which will be held on the campus of Colorado A & M College at Fort Collins.

Nearly forty members and guests of ASAE were registered at the meeting and attended the Section dinner on April 10, the high point of which was an inspiring address by ASAE president, Ivan D. Wood, which dwelt with the future opportunities and challenges for agricultural engineers.

Harwell to Head Georgia Section

AN INSPECTION of Greenwood Farms near Thomasville, Ga., plus the traditional fishing expedition to the Gulf near St. Marks, were the main features of the spring meeting of the Georgia Section, American Society of Agricultural Engineers, on April 10-12. Greenwood contains 18,000 acres and under private ownership and management is pointing the way toward more efficient and profitable timber management and seed corn production under South Georgia conditions.

At the business meeting on Friday evening, James W. Harwell, soil conservationist, Soil Conservation Service, was elected chairman, succeeding J. T. Phillips, Jr., vice-president, Lilliston Implement Co. Bud S. Moss, manager, rural division, Georgia Power Co., was elected vice-chairman, and Warren E. Garner, assistant agricultural engineer, University of Georgia, was re-elected secretary-treasurer. Over 50 members and guests registered for the meeting.

Saturday, April 11, was spent on the Gulf trolling for King Mackerel. Each boat reported catches of 15 to 25 good-sized fish, and everyone had enough to take home for proof that it was a fishing trip.

Hawaii Section Meeting

ENGINEERING problems in production of paper from sugar cane bagasse were reviewed by W. A. Robinson, Hawaiian Sugar Planters Assn.,, at the March 23 meeting of the Hawaii Section. This was an evening meeting at the Agricultural Engineering Institute, University of Hawaii.

Mr. Robinson indicated that cleaning, transportation, and storage of the bagasse present the major problems, and that substantial changes in the field and factory operations of a sugar mill might be necessary to establish paper making as a profitable by-product operation. A lively discussion followed the presentation.

Warren Gibson, chairman of the Section, presided. He announced that the Section executive committee had approved a special assessment of $1.00 per Section member for 1953. Lawrence W. Larson, secretary-treasurer, reported the meeting.

1952 ASTM Standards Book

AMERICAN Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., announces that its 1952 book of standards is completed and will shortly be ready for distribution. It is published in seven parts as follows: (1) ferrous metals; (2) non-ferrous metals; (3) cement, concrete, ceramics, thermal insulation, road materials, waterproofing, and soils; (4) paint, naval stores, wood, fire tests, sandwich constructions, building constructions; (5) fuels, petroleum, aromatic hydrocarbons, and engine antifreezes; (6) rubber, plastics, and electrical insulation, and (7) textiles, soap, water, paper, adhesives, and shipping containers. Parts 1, 3 and 6 sell for $12.00 each, and parts 2, 4, 5 and 7 for $10.00 each. A complete set of all seven parts sells for $76.00. These prices include postage, except on overseas shipments.

NEWS OF ASAE MEMBERS

BYRON L. BONDURANT, recently resigned as a member of the agricultural engineering staff of the University of Connecticut, to accept appointment as extension agricultural engineer, University of Delaware, Newark.

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EDWIN K. BONNER, JR., who has been employed for several years as a development and design engineer of the S. L. Allen Co., Philadelphia, was recently promoted to the position of head of the company's engineering department.

• • •

M. A. BORDELON, until recently a layout draftsman in the engineering department of the Bettendorf (Iowa) Works of J. I. Case Co., is now employed as a design engineer with the Lockheed Aircraft Corp. at Marietta, Ga.

• • •

BERTHOUD C. BOULTON, recently resigned as production design engineer of the New Idea Farm Equipment Co., and is now executive engineer of Mount Vernon Implement Co., Mount Vernon, N. Y., a subsidiary of the Consolidated Diesel Electric Co.

• • •

LEE C. BOWDEN has resigned as assistant professor of agricultural engineering at Southwestern Louisiana Institute, to accept a position as implement design engineer in the Avery Division of the Minneapolis-Moline Co., Louisville, Ky.

• • •

JOHN J. BRICKLEY, who for the past 28 years has been engaged in supervisory and executive capacities with the United Fruit Co. and the Standard Fruit and Steamship Co. in Latin-America, received appointment on January 1st as vice-president and general manager of the Pampanga Sugar Mills located at Del Carmen, Luzon, P. I. His present address is Box 581, Manila, P. I.

• • •

JAMES H. EBBINGHAUS, since his release from the U.S. Air Force, has accepted employment with the Southwind Division of Stewart-Warner Corp. as test engineer. He is located at the company's plant at Indianapolis, Ind.

• • •

OSCAR E. EGGEN has resigned as vice-president of The Oliver Corp. after 25 years of service with the Company. For many years Mr. Eggen was chief engineer of the Hart-Parr Co. at Charles City, Iowa, and when that company along with others was combined to form The Oliver Corp., he was made chief engineer of Oliver and later plant manager. In recent years he has served the Company as director of engineering and vice-president. His future plans have not been announced.

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FRANK R. HOLLOPETER, following release from active duty with the armed services, is now owner and operator of an irrigation farm near Riverton, Wyo.

• • •

GERALD A. KARSTENS has resigned as extension agricultural engineer, Indiana Agricultural Extension Service, to accept the position of agricultural engineer on the staff of the publication *Feed Age*, published by the American Trade Publishing Co., 520 North Michigan Ave., Chicago.

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W. C. KRUEGER, extension agricultural engineer in New Jersey, was presented a distinguished service award in February by the Co-op Interbreed Cattle Association, at its annual meeting. The Association represents a substantial part of the livestock industry in New Jersey. Mr. Krueger's extension work in the state has been continuous since 1930 and has included contributions to dairy and poultry ventilation, electrification, design of livestock auction buildings, and application of engineering to a wide range of operating problems.

• • •

C. C. LOO, who has been employed at the pilot plant of the Carnation Co. at Oconomowoc, Wis., has recently been transferred to the research laboratories of the company at Van Nuys, Calif.

• • •

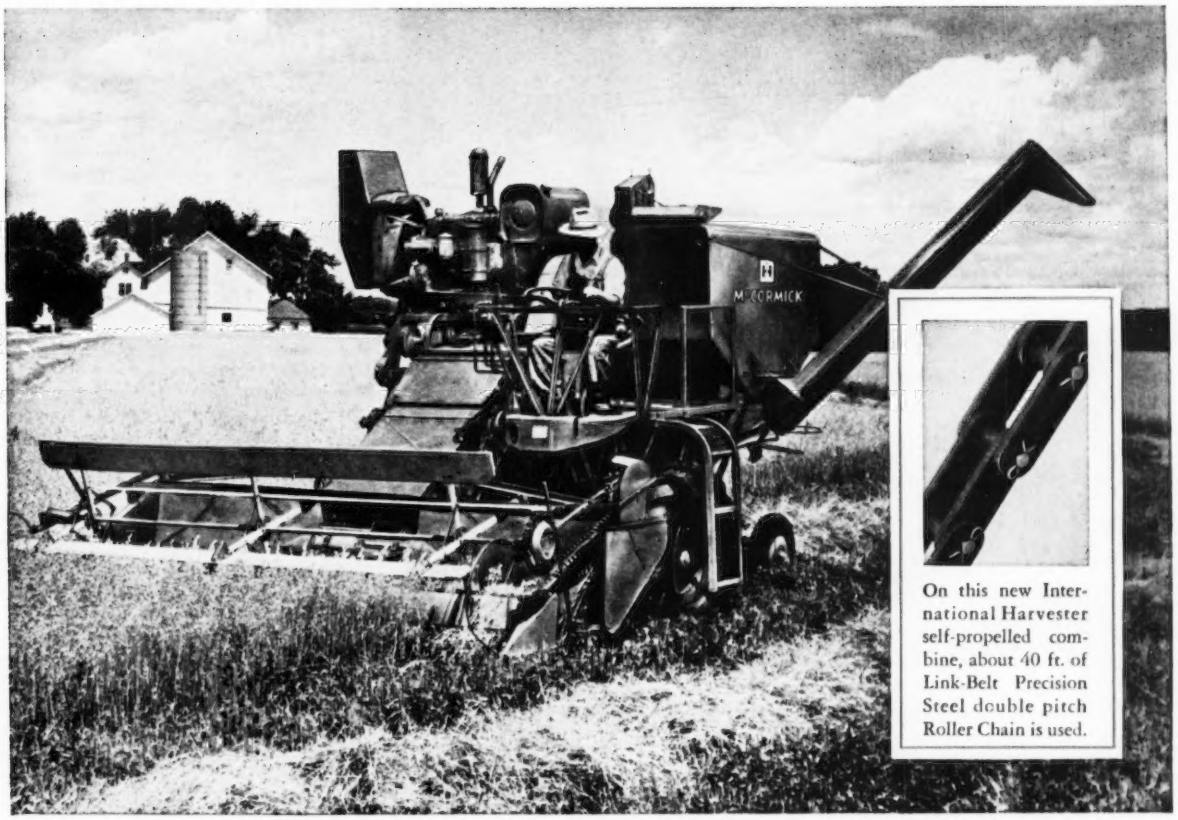
DALE G. MILLER, who joined the Society in 1951 and who until recently has been on duty with the armed services, is now employed as a junior engineer on development and testing in electronics at the Mishawaka plant of the Bendix Products Div. of Bendix Aviation Corp.

• • •

JOHN S. PERRY has resigned as instructor in agricultural engineering at Pennsylvania State College, to accept appointment to the agricultural engineering staff of Michigan State College, E. Lansing.

• • •

WALTER F. WINROTT, SR., Pacific Pipe Co., San Francisco, was guest speaker on February 6 at a meeting of the Philippine Society of Agricultural Engineers held in Manila. For three weeks following the meeting he toured the Philippine Islands, and during the tour he addressed several local meetings of the PSAE held at sugar centrals on the subject of sprinkler irrigation.



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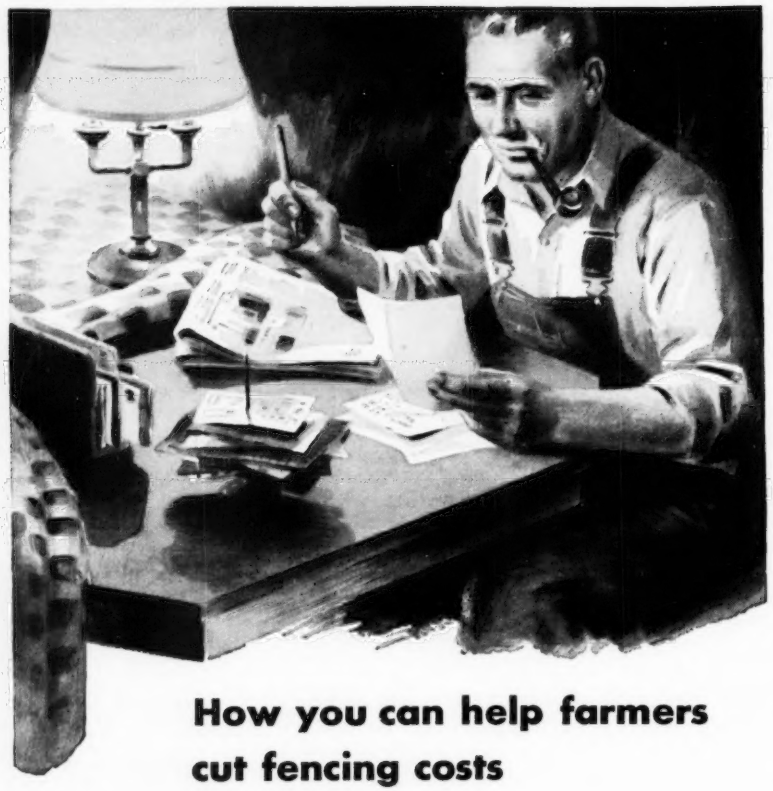


How you can help farmers cut fencing costs

• Recommend pressure-creosoted fence posts—they last *many times longer* than any type of untreated wood post. And the longer a fence stands without major repair or replacement, the less it costs per year of service. On some installations, pressure-treatment with creosote has increased the life of fences as much as 5 times.

Longer-lasting creosoted posts greatly reduce the time and labor used in checking and repairing fences. And they limit fence damage caused by grass fires. *Creosoted fences* resist combustion; so a grass fire is not likely to level a creosoted fence.

For complete information, write to Koppers Co., Inc., Tar Products Division, Pittsburgh 19, Pa.

KOPPERS COMPANY, INC., PITTSBURGH 19, PA.

Tar Products Division

DISTRICT OFFICES: Woodward, Ala. · Chicago, Ill., 122 S. Michigan Ave.
New York, N. Y., 350 Fifth Ave. · Boston, Mass., 250 Stuart Street
Los Angeles, Calif., 727 E. Gage Ave. · Pittsburgh, Pa., Koppers Building

KOPPERS

All Standard Specifications

Creosote

The Performance-Proved Wood Preservative

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

AIHARA, KENJI — Shop superintendent, A. F. Stubenberg, Ltd. (Mail) Honolulu 16, T. H.

ANDERSON, JUDSON H. — Account executive, Alfred Colle Co., 2446 Park Ave., Minneapolis 4, Minn.

BEVILLE, BISHOP C. — Agricultural engineer, Soil Conservation Service, USDA, Sarasota, Fla. (Mail) 5361 South Tamiami Trail

BJERKAN, ARTHUR J.—Product Design Engineer, John Deere Wagon Works, Moline, Ill. (Mail) 2530 14th St.

CLAYTON, WILLIAM G. — Layout draftsman, The Harriman Mfg. Co., Chattanooga, Tenn. (Mail) 528 Alabama St., Memphis 5, Tenn.

CONNER, ROY C.—Sales engineer, Vickers, Inc., Detroit, Mich. (Mail) 19322 Pierson Ave.

DAUGHTRIDGE, JOHN C. — Instructor, Nash County Board of Education (Mail) RR4, Box 47, Rocky Mount, N. C.

DESHMUKH, VASANT G. — Lecturer, M. B. College of Agriculture (Mail) Barve's House, Shinde's Chhaoni; Lashkar-Gwalior (India)

DOUGHTY, ERIC R. — Farm rep., Central Vermont Public Service Corp., Rutland, Vt. (Mail) 7 Christwood Apts., Grove St.

DOUGHTY, FRANK O.—Graduate student, Irrigation Dept., Univ. of California, Davis, Calif. (Mail) 306 E. St.

DOWLING, SAINT ELMO—Mgr., Alexander P. Thomas Farms, Cocoa, Fla. (Mail) P.O. Box 172

DYER, F. L.—Tire engineer, Montgomery Ward and Co., 619 W. Chicago, Chicago, Ill.

EICHELBERGER, WALTER J. — Sales engineer, Food Mach. & Chem. Corp., Fla. Div., Lakeland, Fla. (Mail) 732 S. Johnson

ERFT, DONALD L.—2nd Lt., U.S. Army (Mail) Dorchester, Nebr.

FLAA, IDAN E. — Chief automotive engineer, Ethyl Corp., 525 National Bank of Tulsa Bldg., Tulsa, Okla.

GATES, CECIL R.—Agricultural engineer, Pittsburgh Forgings Co., Coraopolis, Pa. (Mail) RFD 3

GIBBS, JOSEPH W. — Agricultural engineer, Soil Conservation Service, USDA (Mail) 2217 Oneal St., Greenville, Texas.

HENDRICKS, CECIL F.—Mgr. Pump & Irrigation Dept., Polson Implement Co., Seattle, Wash. (Mail) 4234 South 154 St.

HENRETTY, FRANK E.—Project engineer, Consolidated Diesel Electric Corp., Canal & Ludlow Sts., Stamford, Conn.

HINTZ, OTTO E.—Divisional chief engineer, International Harvester Co., 180 N. Michigan Ave., Chicago, Ill.

JOHNSON, VILAS V. — President, American Equipment Distributors, Inc., 333 N. Michigan Ave., Chicago 1, Ill.

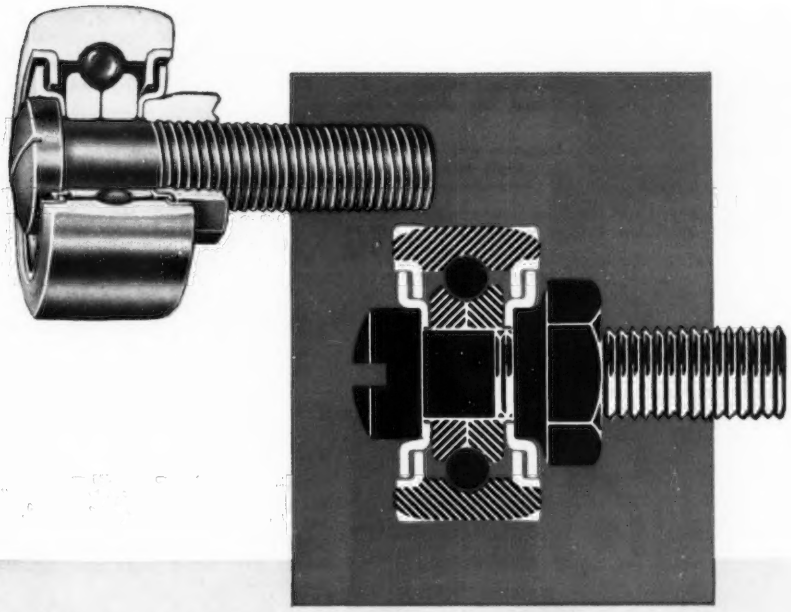
JOHNSON, WILLIAM G., JR.—Agricultural engineer, USDA, Hope, Ark.

LEE, JOSHUA — Industrial engineer, Waialua Agricultural Co., Ltd., Waialua, Oahu, T.H. (Mail) P.O. Box 485

LINDBERG, THOMAS A. — 2nd Lt., U.S. Army (Mail) 406 N. Blue, Walla Walla, Wash.

LISTER, LEONARD O.—Master mechanic, Waialua Agricultural Co., Ltd., Waialua, Oahu, T. H. (Mail) P.O. Box 65.

(Continued on page 342)



Low in original cost, BCA Cam Follower Bearings cut installation costs, too!

This *package unit* includes a pre-lubricated sealed bearing and a mounting stud. So, in addition to costing less initially, BCA Cam Follower Bearings save substantially on installation time.

BCA Cam Follower Bearings stand up to the terrific punishment of agricultural service. They give outstanding performance used in connection with hay baler cams and in forage harvester pickup attachments. The thick-sectioned outer race is case hardened to withstand the shock common to these cam applications. BCA cam follower bearings are slightly crowned to assure better contact with the cam.

BCA has made many contributions to the solution of the bearings problems peculiar to farm equipment. Perhaps we can solve *your* bearings problems.

BCA

radial, thrust, angular-contact Ball Bearings

BEARINGS COMPANY OF AMERICA

LANCASTER • PENNSYLVANIA

Applicants for Membership

(Continued from page 340)

LUNDELL, VERNON J. — President, Lundell Mfg. Co., Cherokee, Iowa

MCCRACKEN, JOHN H. — Owner, McCracken Tractor Co., Gazelle, Calif. (Mail) P.O. Box 100

MCDOWELL, ROBERT F. — Agricultural engineer, Morris Engineering Co., LaPorte, Ind. (Mail) 202 Niesen

MEYER, ELMER T. — Assistant manager, agr. div. sales, Crucible Steel Co. of America, Pittsburgh 30, Pa. (Mail) 2214 Oliver Bldg.

POLSTON, OLIVER E. — Soil conservationist, USDA (Mail) P.O. Box 567, Sebring, Fla.

SAREEN, K. L.—Assistant director operations, Central Tractor Organization, Gov. of India, Bairagarh, Bhopal, India

SCHWEGLER, ROY F. — Project engineer, J. I. Case Co., Rock Island, Ill. (Mail) 4207 11th St.

SELF, HORACE C.—Irrigation specialist, Farmland Irrigation Co. (Mail) P.O. Box 326, Kelseyville, Calif.

SMITH, LOUIS C.—Farm superintendent, Women's Prison, Raleigh, N. C.

SMITH, WAYNE H.—Area engineer, Soil Conservation Service, USDA, P.O. Box 351, DeFuniak Springs, Fla.

STRICKLAND, LEO E. — Agricultural engineer, (SCS) USDA (Mail) Box 310, Lake City, Florida

TALAK, JOHN F. — Hydraulic engineer, J. I. Case Co. (Mail) 409 15th St., Silvis, Ill.

VAN BLARCOM, WILLIAM A.—Vice-president, Douglass Mfg. Corp., DeQueen, Ark.

WAKEFIELD, HAROLD R. — Agricultural engineer, United Co-operatives, Inc., Alliance, Ohio (Mail) 191 W. Main St.

WALLACE, ARTHUR F.—Factory and shop superintendent, Waialua Agricultural Co., Ltd., Waialua, Oahu, T. H. (Mail) P.O. Box 4

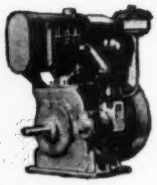
WEBER, HOWARD J.—Vice-president, Porterville Pump Shop, 412 S. Main St., Porterville, Calif.

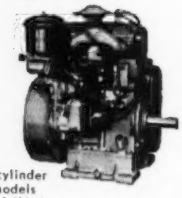
TRANSFER OF MEMBERSHIP GRADE

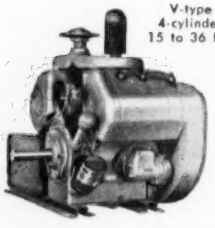
BARTLETT, HOWARD D.—Assistant agricultural engineer, agr. eng. dept., Univ. of Maine, Orono, Me. (Associate Member to Member)

WISCONSIN *Air-Cooled* ENGINES

Fit the Job and the Machine


4-cycle single cylinder 6 to 9 hp.


2-cylinder models 7 to 14½ hp.


V-type 4-cylinder 15 to 36 hp.

For powering balers, combines, cornbines, forage harvesters, garden tractors, pumps, sprayers, small rotary tillers, loaders, conveyors, electric generating plants and many other types of equipment . . . you will find Wisconsin Air-Cooled Engines cutting costs and speeding up the job on thousands of farms everywhere.

Because Wisconsin Heavy-Duty Air-Cooled Engines are supplied in a complete power range, from 3 to 36 hp., in 4-cycle single cylinder, 2- and 4-cylinder types, there is an ideal size to fit all types of power applications within this range . . . without wasted power and with maximum power benefits.

Heavy-duty construction combined with extremely compact design and light weight are features to consider in selecting the right power to fit both the machine and the job. And dependable AIR-COOLING assures trouble-free cooling under all climatic conditions.

For Most H.P. Hours of on-the-job service from your engine-powered equipment . . . specify "WISCONSIN". Descriptive literature and engineering data on request.

WISCONSIN MOTOR CORPORATION

World's Largest Builders of Heavy-Duty Air-Cooled Engines

MILWAUKEE 46, WISCONSIN

A 7255-½-IR

NEW BULLETINS

Tips on Purchasing Motor Oil, by Dale O. Hull. Iowa State College (Ames), Pamphlet 186 (January, 1953). An 8½ x 11-inch, four-page leaflet discussing the oil selection problem briefly, and explaining the new API service classification of motor oil.

Selecting a Heating System for Your Home, by John C. Campbell. Oregon (Corvallis) Federal Cooperative Extension Bulletin 720 (revised March, 1953). Summarizes considerations of cost, methods of heat transfer, kinds of heating systems, and available fuel. Equipment discussed includes the heating stove, floor furnace, wall heater, warm-air central heating system, hot-water central heating system, steam central heating system, baseboard heating, radiant panel heating, the heat pump, electric heating, and the fireplace. Fuels mentioned include sawdust, wood, coal, fuel oil, gas and electricity.

The L-Shaped Stronghold Fence Staple, by E. George Stern. Virginia Polytechnic Institute Wood Research Laboratory (Blacksburg) Bulletin No. 11 (March, 1953). Reports tests and test results on a new form of staple with one threaded shank, designed to maintain holding power for the service life of wire fencing.

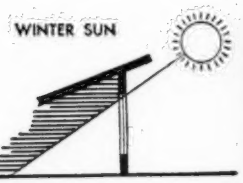
28th Annual Report of the Kansas Committee on the Relation of Electricity to Agriculture. Department of Agricultural Engineering, Kansas State College (Manhattan). Limited circulation.

This report covers the 1952 annual meeting of the Committee, and matters presented at that meeting, including a rural electrification survey, studies on heat pumps, grain drying, feed processing, silage handling, phase converters, and other activities sponsored by or reported to the Committee.

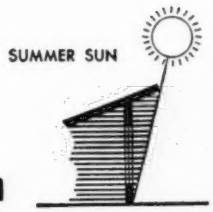
Relation of Shrinkage to Moisture Content in Concrete Masonry Units. Housing Research Paper 25 (March, 1953), Housing and Home Finance Agency (Washington 25, D. C.) (Superintendent of Documents, 20 cents).

Reports studies of the tendency of concrete blocks to shrink on drying, causing cracks in work completed before the drying and shrinkage take place.

Upstream Flood Prevention in the Western Gulf Region, by Harold M. Kautz, Region 4, Soil Conservation Service, USDA (Fort Worth, Texas) January, 1953. Pictorial story of flood damage and upstream prevention measures, explained with a minimum of text. Estimated average annual benefits are shown for two watersheds, on which they are greater than total costs.

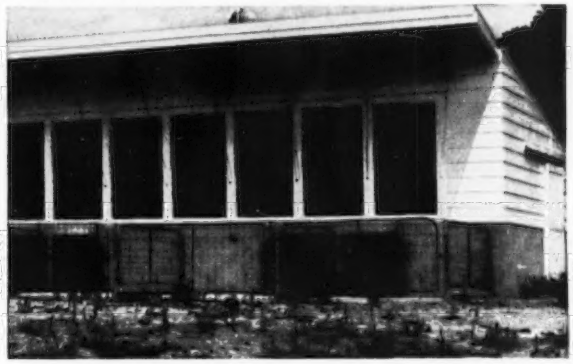


Use the sun for WARMER, DRIER BUILDINGS in winter



Control the sun for COOLER BUILDINGS in summer

Hog house located at Michigan State College, East Lansing.



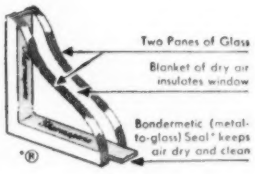
Sunshine has long been regarded as beneficial to animals. It provides winter warmth especially valuable in protecting pigs, calves, chicks and lambs. It has germicidal benefits. And in helping to keep buildings drier it contributes to a healthier environment for livestock.

When large glass areas are used for these winter benefits, windows should be insulated to reduce heat loss through glass and shaded to keep out unwanted summer sunshine.

Fortunately, nature makes sun control easy. The sun is low in the winter sky so that it penetrates deeply into buildings. In summer, its more vertical rays are easily shaded from windows. Getting sun when it is needed—and only when needed—is a matter of:

1. Orientation—placing the building on an east-west axis, with large windows facing south.
2. Shading—providing a roof overhang or other device which will allow winter sun to enter, but shade out summer sun.

Insulation helps keep heat out in summer, just as it helps keep heat in during the winter. That's another reason why *Thermopane** insulating glass is being used more and more in farm service buildings. Widely used for winter warmth, *Thermopane* also provides extra summer protection. *Thermopane* is the easiest way to insulate windows. It is installed much like single glass, in frames made deeper to take care of its greater thickness.



LOF GLASS FIBERS PLASKON FIBER GLASS

Thermopane INSULATING GLASS

Thermopane is now available in low-cost standard units made especially for farm service buildings—for fixed or ventilating sash of wood or steel.
Thermopane is sold by glass and building supply distributors and dealers throughout the U. S. Send the coupon for more information.

FREE FOLDER

"IMPROVED FARM BUILDING DAYLIGHTING"

Libbey-Owens-Ford Glass Co.
1853 Nicholas Bldg., Toledo 3, Ohio

Please send me a free copy of "Improved Farm Building Daylighting."

Name _____
(PLEASE PRINT)

Address _____

Town _____ State _____

DEPENDABLE PERFORMANCE calls for STOW

Picture courtesy BROOME G. L. F. ELEVATOR

G.L.F. depends on STOW flexible shafting for speedy grain delivery!

"Since installing STOW flexible shafting on our bulk feed delivery units, we have lost no time due to breakdowns and have had no maintenance problems in over five months of continuous service", says Mr. Joseph Collins, manager, Broome G.L.F. Elevator.

This STOW flexible shaft application replaces a universal joint series which would not stand up under the rugged conditions to which it was subject during deliveries to farms. Primary cause of the failure, according to Mr. Collins, was the steep angles through which the universal joints had to operate. Prior to the installation of STOW flexible shafting, Broome G.L.F.'s grain delivery units suffered frequent breakdowns, each of which involved three or four-hour delays and upped delivery costs.

This is another excellent example proving the efficiency, the practicability of STOW flexible shafting. Why not consult with STOW engineers on *your* next power transmission problem?

WRITE TODAY for your FREE Torque Calculator and Bulletin 525 containing complete data on STOW flexible shafting. No obligation, of course.

STOW

first in flexible shafting since 1885

39 SHEAR STREET
BINGHAMTON, NEW YORK

NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

A New Pickup Baler

International Harvester Co., Chicago, announces the new McCormick No. 55 baler—an automatic-tying, engine-driven pickup baler which makes a new and heavier 15 x 19-inch bale. It is made in both twine-

New McCormick No. 55 baler

tying and wire-tying models. The tying mechanism has been simplified. The machine has a low-level pickup designed to provide gentle action to save valuable leaves.

New V-Belt Catalog

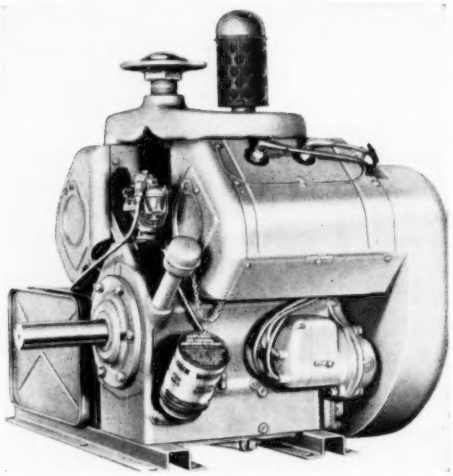
Raybestos-Manhattan, Inc., Inc., Passaic, N. J., will send on request a copy of its new fractional horsepower V-belt catalog for use in connection with servicing light-duty applications. The catalog lists belts according to the new industry-standard numbering system. Various types of machines are listed together alphabetically by company or trade names for convenience in determining the proper belt.

New Auxiliary Power Unit

Wisconsin Motor Corp., Milwaukee, Wis., has announced, as the most recent addition to its heavy-duty air-cooled engine line, the new Model VG4D, 4-cycle, V-type, 4-cylinder engine. It has 3½-in bore, 4-in stroke, 15-cu-in displacement, and develops a peak rating of 36 hp at 2200 rpm.

It is a smooth-running, even-firing engine, well equipped to provide the extra margin of power needed for operating equipment within a 25 to 36-hp range.

It is of light weight and compact in design to simplify the problem



New Wisconsin VG 4D standard 25-36-hp engine with side-mounted fuel tank

of engine installation on modern equipment. Usual Wisconsin engine features are a part of the new VG4D, including tapered roller main bearings, dynamically balanced forged crankshaft, mirror finish on crank pins, Stellite-faced exhaust valves, valve seat inserts and honed cylinders for long, dependable, heavy-duty engine life. In addition valve rotators of the positive type are furnished on the exhaust valves as standard equipment.

Efficient, positive cooling is obtained even at extremely high temperatures from a large fan cast in the flywheel which forces a strong blast of air across and around the cylinders and heads.

(Continued on page 346)

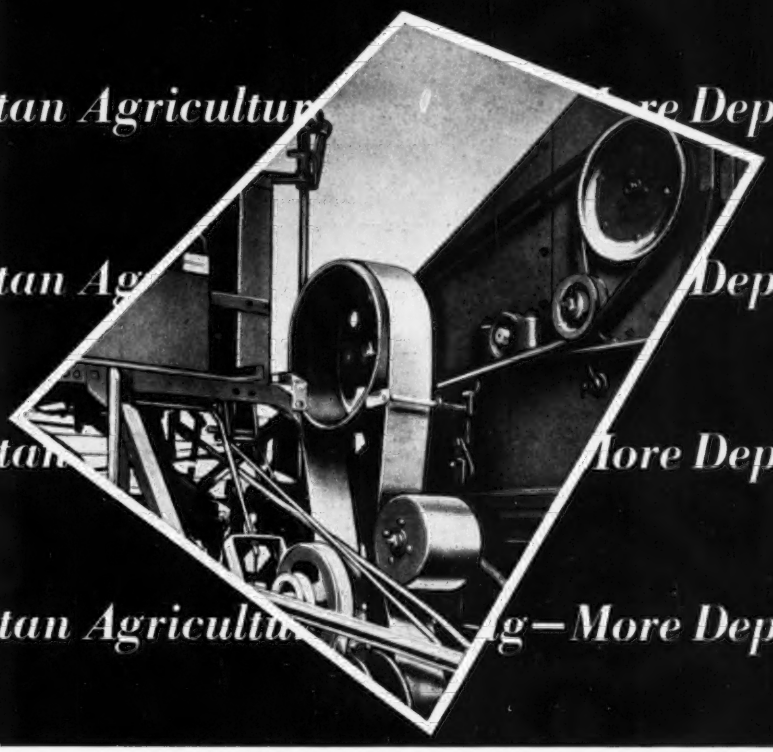
Manhattan Agricultural Belting—More Dependable

Manhattan Agricultur re Dependable

Manhattan Ag Dependable

Manhattan lore Dependable

Manhattan Agricultu g—More Dependable



LONG LIFE, STRENGTH, FLEXIBILITY, and uniform performance under all operating conditions — these are the qualities of dependability which manufacturers of farm equipment get when they specify "Manhattan Agricultural Belts."

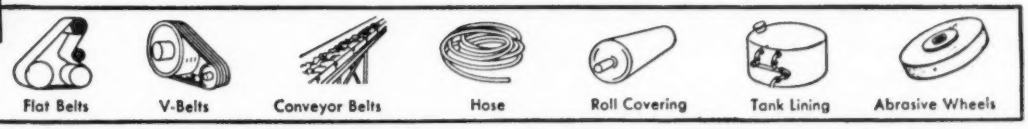
Manhattan's investment of 60 years of research in the development of agricultural rubber products has produced the most reliable and economical belts available today. Made for all power applications, Manhattan Agricultural V-Belts and Condor Whipcord Endless Belts are designed to meet the most rigid modern requirements of farm equipment manufacturers.

To maintain its constant leadership in rubber belt technology, Raybestos-Manhattan, Inc., works closely with OEM engineers in the design of power transmission drives for all agricultural operations. R/M engineers are always ready to discuss your belting problems with your engineering department.

R/M

MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.



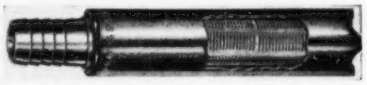
Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings
Asbestos Textiles • Teflon Products • Packings • Sintered Metal Parts • Bowling Balls

NEWS FROM ADVERTISERS

(Continued from page 344)

New Suction Strainer

Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., will send on request a copy of data sheet No. 5470 describing its new suction strainer unit which it has developed to fit all farm spraying equipment. The complete unit consists of three pieces that can be quickly disassembled by hand for easy cleaning. It is designed to withdraw liquids



Spraying Systems suction strainer

to a very low level. An outer brass casing protects the strainer element from damage. The outlet end connects directly to hose. The strainer is supplied in all brass or aluminum.

New Massey-Harris Catalog

Massey-Harris Co., Racine, Wis., will send on request a copy of its new 1953, 48-page catalog, illustrating and describing its full line of farm machines and implements. The contents include all tractor models, the complete line of tractor-mounted tools, haying tools, pull-type implements, wagons, mounted and self-propelled corn pickers, and self-propelled combines.

Anhydrous Ammonia Valves and Fittings

Henry Valve Co., 3215 North Ave., Melrose, Ill., will send, on request, a copy of its catalog No. 801 describing its line of anhydrous ammonia valves and steel fittings for equipment for applying anhydrous ammonia as a soil fertilizer.

New Fencing Booklet

United States Steel Corp., Pittsburgh 30, Pa., has made available an illustrated folder, entitled "Fences that Pay." It shows recommended construction with pressure-creosoted wood posts, including bracing, spacing, grounding, stretching, maintenance and other details. Requests for copies may be addressed to the Company's market development division, Room 2831, 525 William Penn Place, Pittsburgh 19, Pa.

Durability of Gears

The International Nickel Company, 67 Wall St., New York 5, N.Y., will send on request a reprint of an article of five pages, with illustrations and charts, entitled "Evaluating Surface Durability of Gears," which describes an improved technique aimed to test gears under controlled conditions of load, temperature, speed and lubrication, eliminating other variables. Test results in deterioration by pitting rather than by tooth breakage are given. It discusses a noise meter used to determine the point at which failure begins. Test machine, specimen and procedure are described. Typical test data demonstrates the results obtainable.

New Double-Cog V-Belt

Dayton Rubber Co., Dayton, Ohio, announces development of a new double-cog, all-purpose V-belt for any type of agricultural drive requiring speed changes. The belt is built with preformed cogs. The contour and cog spacing are accurately controlled which makes possible mathematically and mechanically exact cogs, which in turn eliminates variations and vibrations in the belt, together with the major cross-sectional distortions produced by flexing. The belt provides more effective utilization of the new blend of synthetic rubber of which it is made, and the cogs are able to take up the compression and relieve strains and distortions, cutting down heat buildup and giving the belt a cooler running and longer life.

Suction Filter for Sprayers

Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., will send on request data sheet No. 5610 on their new suction filter for use with sprayers where the water used contains sand or silt. The filter is made

Spraying Systems suction filter

of special felt washers held by and tightly compressed around a brass core. By loosening a single holding screw, the felt washers are easily removed for cleaning. The outlet end is threaded for ¾-in garden hose connection.

New "Monarch"
BY MILSCO America's Leading Seat Specialists
FOR MANUFACTURERS OF MOBILE EQUIPMENT
No. 344 With Or Without Fore And Aft Attachment
★4 Point Body Comfort
The new Milsco "Monarch" features deep cushion comfort with full 4-point body support. Ruggedly built; attractively styled. Designed for stepped-up work efficiency on many types of mobile equipment. (Sold to equipment manufacturers only.) Write for catalog on your company letterhead.
MILSCO MFG. CO.
2732 N. THIRTY-THIRD STREET
MILWAUKEE 45, WISCONSIN
LAMINATED PLYWOOD BACK AND SEAT
GENUINE OR ARTIFICIAL LEATHER
TUBULAR STEEL FRAME
FOAM RUBBER OR LATEX COVERED SISAL
SPECIAL LONG LIFE COIL SPRINGS
Milsco
MILWAUKEE

More Weight on Steers, Hogs! The ratio of feed cost to weight gain goes up rapidly as temperature rises. Make more with livestock kept cooler by aluminum.

Stretch Profit Two Ways with Rustproof, Heat-Reflective

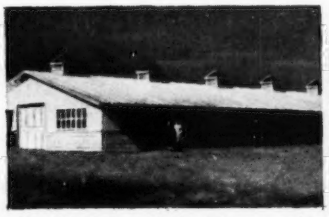
REYNOLDS *Lifetime* ALUMINUM ROOFING, SIDING, INSULATION

Stretch income *up* with aluminum's heat reflection. Aluminum keeps buildings up to 15° cooler in summer... warmer in winter, too. That's a very *important* profit factor. And at the same time push costs *down* with the roofing and siding that never rusts, never needs painting, and lasts a lifetime with practically no maintenance.

The most modern farm buildings are being designed for aluminum. Make your plans this modern way. Military demands for aluminum limit supply, but capacity is rapidly increasing. See your dealer. Write for literature.

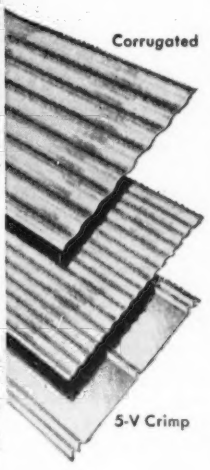
Reynolds Metals Company,
Building Products Division,
Louisville 1, Kentucky

Reynolds Aluminum Insulation is a quick way to get this heat-reflecting advantage...foil on kraft paper, being applied, above. Reynolds also serves the farmer with Aluminum Gutters, Windows, Flashing, Cable (ACRS), Portable Irrigation Pipe, Siphon Tubes, Paint Pigment, and Freezer Foil.



More Profit From Poultry! Owner of this Georgia broiler plant says his heat-reflecting aluminum roof means higher market prices sooner...plus lower winter fuel bills. Egg production goes up, too.

Increases Milk Yield! Tests prove that every 5° above 85° means two to seven pounds of milk loss per day. Aluminum keeps barns up to 15° cooler. Figure the difference that makes in dollars.



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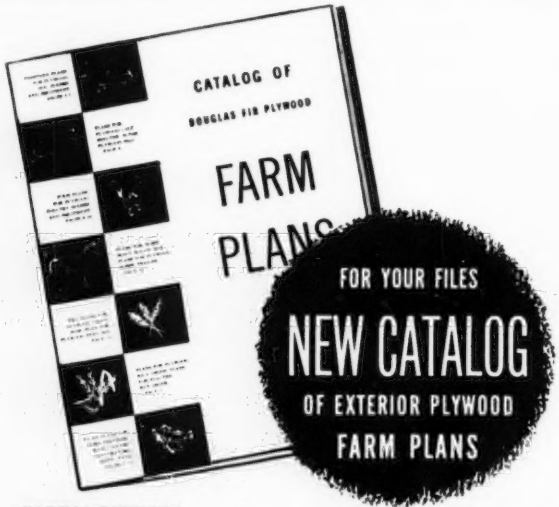

PARTIAL CONTENTS

- HOG HOUSES
- FARROWING HOUSES
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NEW BOOKS

THE AGRICULTURAL TRACTOR, by P. H. Southwell, (Member ASAE). Cloth xiii + 170 pages, 5½ x 8½ inches. Illustrated and indexed. Temple Press, Ltd., (Bowling Green Lane, London, E.C. 1, England). 15 s net.

Here is a basic text and reference on the subject written from a British viewpoint. It appears sound without being highly technical, and should prove of value to students of farm mechanization and as a reference for farmers and the farm equipment industry. Chapters cover subject survey, engines for agricultural tractors, engine performance, fuels and oils, the transmission system, the ground-drive components, power losses in the agricultural tractor, further design factors, tractor performance and testing, tractor operation and choice, and future trends.

• • •

HOW TO REPAIR AND BUILD FARM EQUIPMENT WITH ARC WELDING. Paper, 128 pages, 5¾ x 8½ inches. Illustrated. Lincoln Electric Co., (Cleveland 17, Ohio). 50 cents postpaid in USA, 75 cents elsewhere.

This new guide carries through from basic instructions for the beginner to new applications and work requiring considerable skill. Pictures carry a major part of the instruction. Subjects covered include theory of arc welding, arc welding equipment, protective equipment, general safety rules, how to use the farm welder, fundamentals of welding, repairing broken parts, building handy farm equipment, maintaining farm tractors, build-a-tool plans, indentification of materials, procedures for farm electrodes, useful information, and farm welders.

• • •

WEED CONTROL, by W. W. Robins, A. S. Crafts, and R. R. Raynor (Second edition). Cloth, xi + 503 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., Inc. (330 W. 42nd St., New York 36, N. Y., also Toronto and London.) $8.00.

Since the first edition was published ten years ago there has been considerable progress in methods, materials and equipment for weed control. With this and the older information still current the authors provide a text and reference dealing with the subject as indicated by the following chapter headings: Weeds and human affairs, reproduction of weeds, methods of preventing the introduction and spread of weeds, ecology of weeds, principles of weed control, tillage methods of weed control, biological control of weeds, use of chemicals in weed control, properties and functions of herbicides, selective herbicides—foliage contact applications, selective herbicides—foliage contact applications oils, selective translocated herbicides—foliage contact applications—hormone-like substances, selecti e herbicides—root applications, nonselective herbicides — foliage contact applications, nonselective herbicides — translocated foliage applications, nonselective herbicides—root applications, nonselective herbicides—root applications (continued), evaluation of combinations of chemical applications, equipment for applying herbicides, special weed problems—weeds of grasslands and turf, special weed problems — cropped areas, special weed problems — uncropped areas, special weeds.

• • •

PRACTICAL ELECTRICAL WIRING, by H. P. Richter (Fourth edition). Cloth, x + 602 pages, 5½ x 8 in. Illustrated and indexed. McGraw-Hill Book Co., Inc. (330 W. 42nd St, New York 36, N. Y. Also Toronto and London). $6.50.

This established reference is brought up to date in line with the 1951 National Electrical Code and materials and methods accepted in wiring practice since publication of the third edition in 1947. Part and chapter headings are as follows: Part 1. Theory and basic principles, chapters on underwriters and codes, electricity: basic principles and measurements, a-c and d-c; power factor; transformers, basic devices and circuits, overcurrent devices, types and sizes of wires, selection of proper wire sizes, wire connections and joints, theory of grounding, outlet and switch boxes, different wiring methods, branch circuits and service entrance, adequate wiring, good lighting, residential and farm motors.

Part 2. Actual wiring: residential and farm, chapters on planning an installation, installation of service entrance and ground, installation of specific outlets, finishing: installation of switches and other devices, miscellaneous wiring, old work, farm wiring, isolated and stand-by power plants, wiring apartment houses, code requirements with respect to wire.

Part 3. Actual wiring: nonresidential projects, chapters on planning non-residential installations, miscellaneous problems in nonresidential wiring, non-residential lighting, wiring for motors, wiring schools and churches, wiring offices, wiring stores, wiring miscellaneous occupancies.

• • •

THE TRACTOR FIELD BOOK (1953 edition). Edited by James A. Basselman. Paper, 404 pages, 9 x 12 inches. Illustrated and indexed. Farm Implement News Co. (Chicago 5, Ill.)

Reference data on the design, production and sale of tractors and power farm equipment, organized into sections on tractor data, Nebraska tests, tractor service, garden tractors, rotary tillers, power units, farm equipment, and industry standards.

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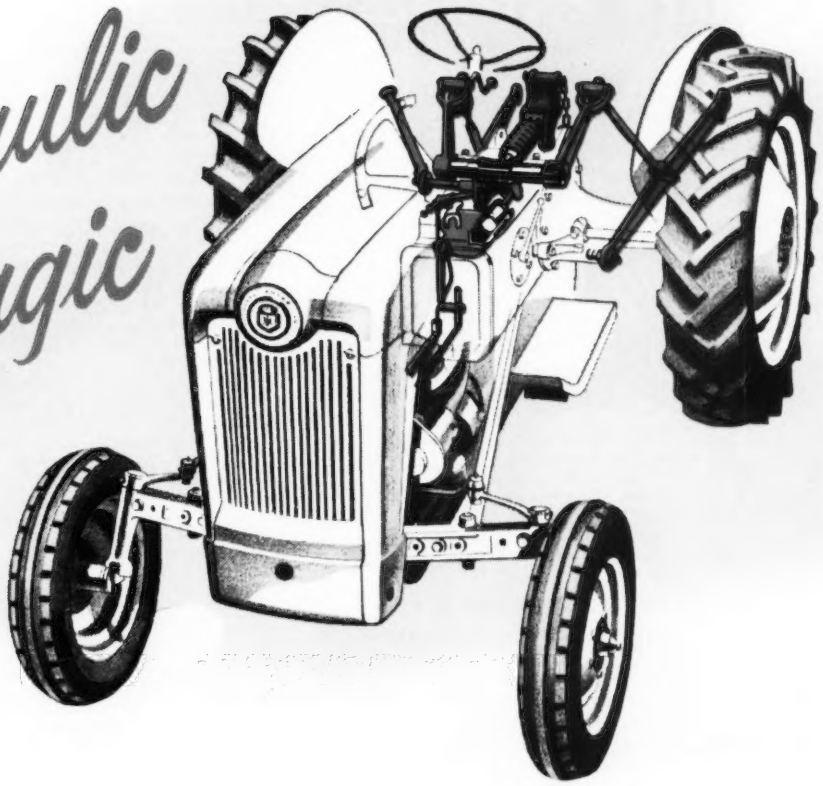

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issues of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — 1952 — OCTOBER — O-767-583, 785-591. DECEMBER—O-797-597. 1953—FEBRUARY—O-907-605, 911-606, 7-501, 6-502, 10-503, 11-504. MARCH—O-50-505, 74-506, 82-507, 99-509, 102-510. APRIL — O-88-511, 87-512, 90-513, 118-514, 115-515.

POSITIONS WANTED—1952—NOVEMBER—W-823-144. DECEMBER—W-843-146, 832-148, 849-149. 1953—JANUARY—W-827-152, 884-154, 896-157. FEBRUARY—W-893-160, 895-161, 915-162, 16-2, 4-3, 13-4, 21-5, 19-6, 26-7, 27-8. MARCH—W-29-9, 56-10, 67-11, 71-14, 79-15, 85-16, 68-17. APRIL—W-97-18, 64-19, 80-20, 134-21.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEER for graduate work as research fellow on engineering applications in grassland agriculture and crop conditioning. Eastern school. Approximately two years and one summer to complete requirements for MS deg. Farm background and BS deg in agricultural or mechanical engineering. Opening effective June 1. Salary $1440 and other considerations. O-140-516

AGRICULTURAL ENGINEER for field representative of trade association in farm building materials industry. Midwest. Farm background and experience in sales or promotion work. BS deg in agriculture or agricultural engineering, preferably with major in farm structures. Considerable travel required. Good opportunity for advancement. Age 25-35. Salary $350 or more per month to start, according to experience, plus expenses. O-164-517

AGRICULTURAL ENGINEER for resident teaching. Rank either instructor or assistant professor. Fields of farm machinery, power equipment, and rural electrification. New England's largest state university. BS or MS deg in agricultural engineering. Farm background and some teaching or extension service experience. Should like to teach and work with young people. Agreeable personality and neat appearance. Appointment for one year, probably renewable for second year. Permanent appointment prospects uncertain at present. Some opportunity for graduate work. Age 25-35. Salary open, higher than regular scale. O-182-518

AGRICULTURAL ENGINEER for research and teaching in power and machinery. Northeastern school. MS deg in agricultural engineering, or equivalent. Several years experience in college or commercial work. Able to conduct research and teach professional students. Average opportunity for advancement. Opening effective July 1. Salary open, depends on qualifications. O-190-519

AGRICULTURAL ENGINEER for teaching and research in farm machinery and structures. Rank instructor. North Central school. BS and MS degree in agricultural engineering, or equivalent. Farm background. Teaching and research experience desirable, but not essential for man willing to learn. Major interest in farm machinery, farm structures, or both. Able to work with associates and students. Initiative and willingness to assume responsibility. Good opportunity with relatively young and growing department. Good working conditions. New building and good equipment. Salary about $4900, depending on qualifications. One month vacation. O-191-520

NEW POSITIONS WANTED

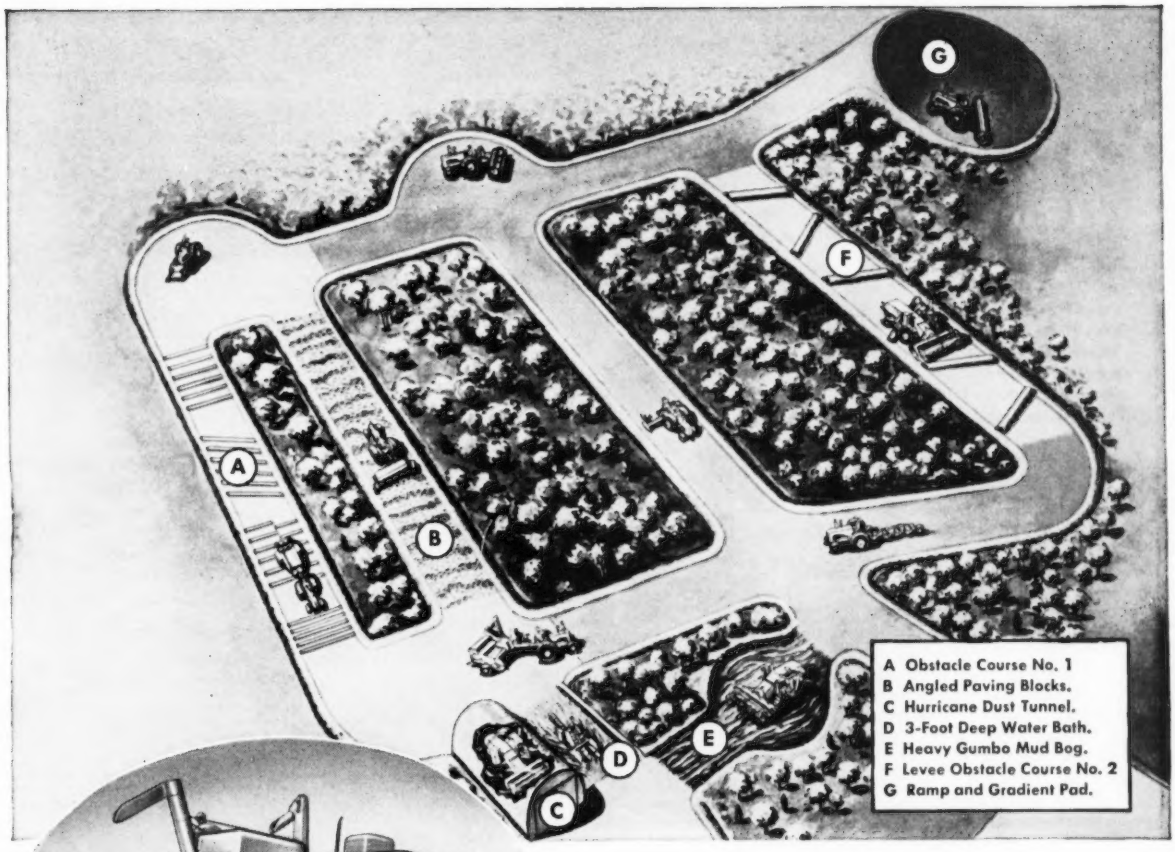
DESIGN, development, research, sales, or service in power and machinery or soil and water field with manufacturer, processor, or distributor in East, North, or West. Reasonable amount of travel. BS deg in agriculture, major in agricultural engineering, 1951, Cornell University. Farm service representative with electric utility since graduation. Farm background and summer work experience previous to graduation. War enlisted service in USNR, nearly 2 yr. Married. Age 27. No disability. Available now. Salary open. W-112-22

EXTENSION, teaching, research, or service in power and machinery, soil and water, or soils and fertilizers, with industry or public service, any location. Willing to travel. BS deg in agriculture expected June 8, University of Florida. Farm background. Farm machinery maintenance, repair, and custom manufacturing at state experiment station three summers. Draft classification 2A. Single. Age 22. No disability. Available June 15. Salary open. W-120-23

AGRICULTURAL engineer for design, development, or research in power and machinery or farm structures in industry or public service, any location. BS deg in agricultural engineering, 1950, Iowa State College. Self employed in custom insect and weed control spraying for farmers one summer. Tool room man and mechanician in experiment station one year, previous to graduation. Engineering for production and sales of prefabricated farm buildings one year. Military service 2 yr, in Transportation Corps, to be completed in May. Wrote specifications and worked on standardization of new military railway equipment. Single. Age 24. No disability. Available June 1. Salary open. W-141-24

AGRICULTURAL engineer for design, development, and research in power and machinery or soil and water with manufacturer, experiment station or federal agency in Midwest. Limited travel. BS deg in agricultural engineering, Kansas State College, 1950. Farm background. Agricultural engineer with S C S, 2 yr. Product education supervisor with manufacturer of farm equipment, one year. War enlisted service in Army Air Force one year. Married. Age 26. No disability. Available on 30-day notice. Salary $5000. W-109-25

(Continued on page 352)


A Obstacle Course No. 1
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E Heavy Gumbo Mud Bog.
F Levee Obstacle Course No. 2
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Rough field conditions are no problem to Massey-Harris Combines. They actually cut their teeth on obstacles courses more severe than normal farming conditions ever approach. That's why Massey-Harris machines have an extra margin of strength in frames and braces without excessive weight . . . why they last longer, work smoother.

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Adjoining the test tract are 640 acres of farm land where machines are again tested to prove their actual performance in the field. With the aid of modern electronic devices engineers measure the effects of stress and strain each field operation has on specific parts of the machine. Thus designs are changed and improved until they meet Massey-Harris' rigid standard of quality control.

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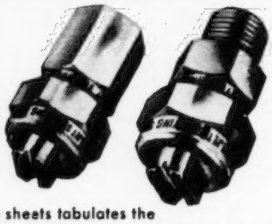

For effective spraying and lowest chemical costs TeeJet Spray Nozzles provide uniform spray pattern, exact spray type, and precision capacity. Performance specified in TeeJet bulletins and data sheets tabulates the exact kind of performance each nozzle will give. You can dependably follow nozzle specifications in selecting TeeJet Spray Nozzles to meet the requirements of all equipment and chemicals.

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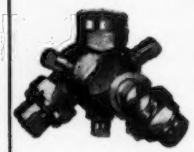

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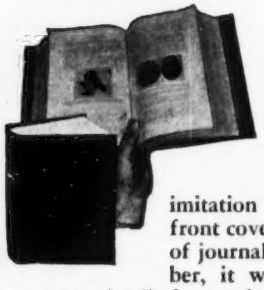

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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to ASAE members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

Personnel Service Bulletin

(Continued from page 350)

AGRICULTURAL engineer for design, development, research, sales, service, or management in power and machinery or product processing with industry or public service. Prefer Midwest location. Will travel part time. BS deg in agricultural engineering, 1950, University of Illinois. Farm background. Service experience in telephone communications. Summer vacation work in all departments of farm machinery distributor. Since August, 1950, agricultural engineer on cotton ginning investigations, including work on gin trash disposal, gin machinery operation and testing, moisture restoration, and stick removal projects. U S Civil Service rating GS-7. Married. Age 29. No disability. Available on reasonable notice. Salary open. W-162-26

TEACHING, development, or management work in power and machinery, farm structures, or soil and water field with public service or industry. Any location, some preference for South. BS deg in agriculture, with majors in agricultural education and agricultural engineering. Citrus grove foreman (200 acres) 6 yr. Typewriter mechanic, 9 mo. Vocational agriculture teacher. Married. Age 31. Wearing hearing aid. Available July 1. Salary open. W-162-27

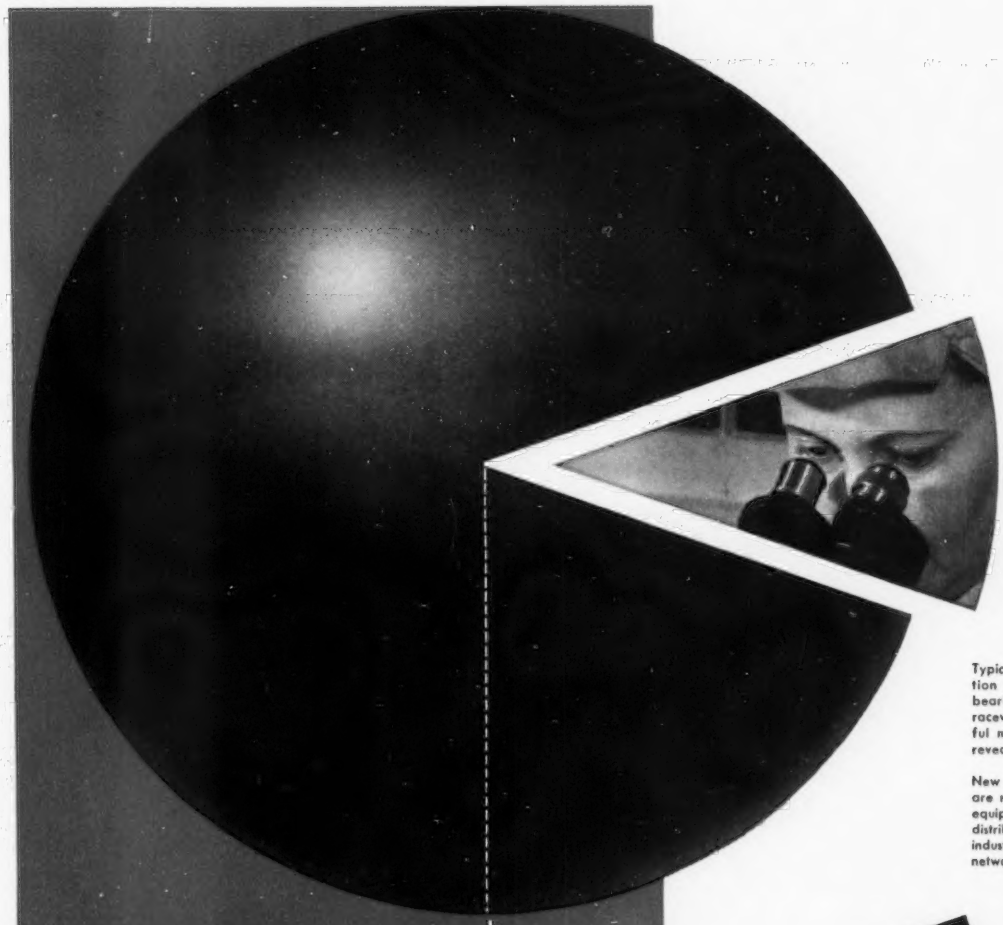
RESEARCH, sales, writing, or market analysis, power and machinery or farm management, with college or industry. Any location, some preference for Midwest or West. Willing to travel ⅓ to ½ time. BS and MS deg in agricultural economics, 1950 and '51, Utah State Agricultural College. PhD in farm management, power and machinery, and marketing 1953, Cornell University. Managed 160-acre irrigated farm 2 yr. Research work, Bureau of Agricultural Economics, 2 summers. Sales work one year. Public relations man for Church of Jesus Christ of Latter Day Saints, in Virginia and North Carolina, one year. War enlisted and commissioned service, U S Navy, 3 yr. Married. Age 29. No disability. Available Sept. 1. Salary $5,500. W-151-28

AGRICULTURAL and mechanical engineer available for sales representative or related management in West or Midwest. Power and machinery field. BS deg in mechanical engineering. Extensive experience as plant manager, chief engineer, director of engineering and vice-president of full-line manufacturer of farm equipment, including dealer and farmer contacts and incidental sales work. Moved West to improve wife's health. Married. Age 52. No disability. Available now. Salary open. W-169-29

AGRICULTURAL engineer for design, development, research, sales, or service in soil and water field, with public service or industry. Prefer Rocky Mountain area or Ohio location. BS deg in agriculture, 1948, University of Wisconsin. Senior standing for CE deg. Graduate study in hydraulic structures and machinery, and in underground water. Registered professional engineer, Illinois. Experience with S C S in survey, drafting, design, and supervision of construction on land leveling, irrigation, drainage, ponds, and erosion control structures, and in current employment as assistant engineer, Illinois State Water Survey, on ground water hydrology. War service in Army Air Force 15 mo, on the line trainee awaiting pre-flight instruction. Married. Age 27. No disability. Available on 30-days' notice. Salary open. W-192-30

AGRICULTURAL engineer interested in development, teaching, sales, service, or writing in power and machinery or soil and water field, with college, manufacturer, or farming operation in U S A. Willing to travel. BS deg in agricultural engineering, 1946, Allahabad University, India. Part time work in Naini College workshop 2 yr, in teaching and manufacture of agricultural implements. Since 1948 agricultural engineer and mechanical supervisor, in turn, with Central Tractor Organization, Government of India. Experience in repair, overhaul, and maintenance of diesel engines, tractors, vehicle, and other agricultural equipment, reclamation and development of land with heavy earth moving equipment and tractors; mechanical cultivation. Farm background. Single. Age 28. No disability. Available now. Salary $3500. W-193-31

DESIGN, development, research, management, or teaching in power and machinery with industry or public service, preferably in Midwest. BS deg in agricultural engineering, 1950. MS deg in agricultural engineering expected in June, 1953. Farm background. Air Force veteran 2 yr. Teaching and mechanization research 3½ yr with University in Southwest Section. Married. Age 27. No disability. Available August 1. Salary open. W-196-32



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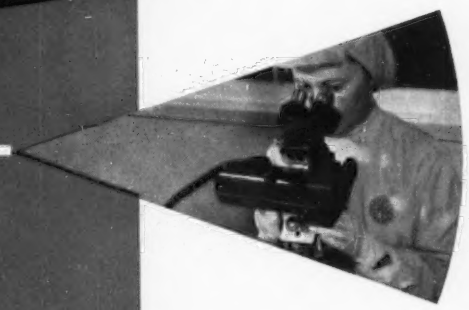

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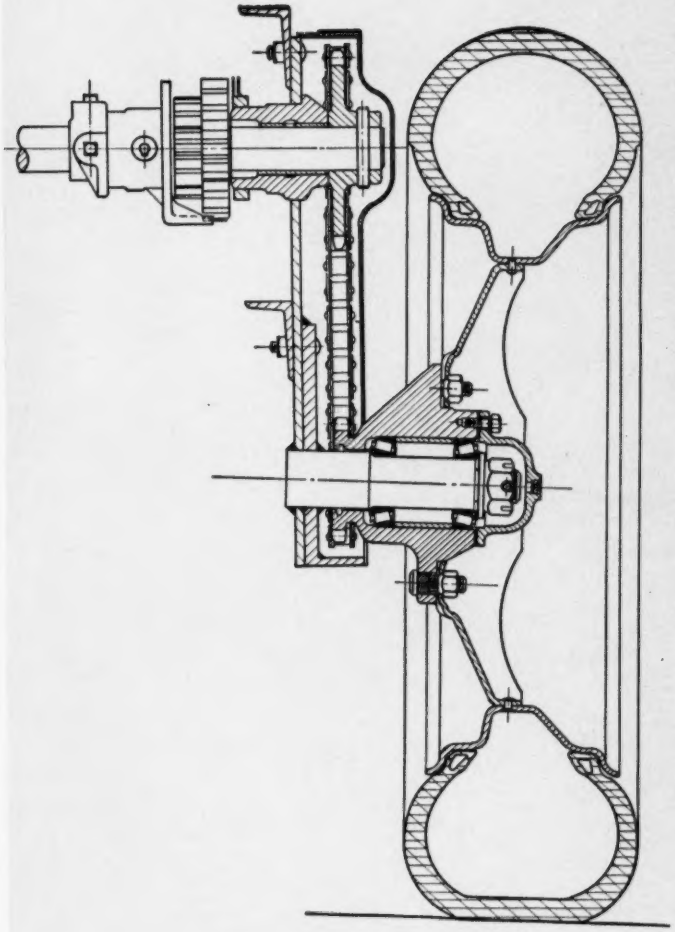
Minneapolis-Moline grain drills get higher towing speeds, more efficient closures with TIMKEN® bearings



Timken bearing application for power grain drill wheels. It's another implement application in which the agricultural engineer has solved three of his biggest design problems with Timken bearings.

THE diagram on the left shows how Timken® bearings are used in Minneapolis-Moline power grain drill wheels to provide a light, low-cost wheel hub design.

Because Timken bearings have true rolling motion and an incredibly smooth surface finish, they reduce friction to a minimum. Higher towing speed of implements is made possible.

Housings and shafts are held concentric by Timken bearings, making seals more effective. Lubricant is kept in, dirt and moisture are kept out. Lubrication and maintenance costs are cut.

When Timken bearings are incorporated into your implement designs, you solve three of your biggest problems: (1) dirt and moisture, (2) combination loads, (3) ease of operation. And implement users are assured of longer implement life, less frequent lubrication, higher towing speeds, less chance of breakdown.

For more information about Timken bearings, write now for your free copy of "Tapered Roller Bearing Practice on Current Farm Machinery Applications". The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

Tapered Roller
TIMKEN BEARING
EQUIPPED

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▱ BEARING TAKES RADIAL ↓ AND THRUST →◫← LOADS OR ANY COMBINATION